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WATER QUALITY AND POLLUTION CONTROL STUDY. JAMES RIVER BASIN

Federal Water Pollution Control Administration
Charlottesville, Virginia

June 1967

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PRELIMINARY-SUBJECT TO REVISION

WATER QUALITY
AND
POLLUTION CONTROL STUDY

JAMES RIVER BASIN

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I. INTRODUCTION

A. Purpose and Scope

Under the provisions of the Federal Water Pollution Control Act (33 U.S.C. 466 et seq), Section 3(a), the Secretary of the Interior is authorized to make joint investigations with other Federal agencies, with State Water Pollution Control Agencies and interstate agencies, and with the municipalities and industries involved, of the condition of any waters in any State or States and of the discharge of any sewage, industrial wastes, or substance which may adversely affect these waters. These investigations are for the purpose of preparing and developing comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof.

This Working Document, by describing the immediate water pollution control action needed in the James River Basin, represents the first step in the development of a comprehensive program to control water pollution in the Basin.

The principal objectives of the investigation and report are to:

1. Delineate existing and potential water quality problems in areas producing significant municipal, industrial, and/or other wastes, and identify sources.
2. Summarize immediate pollution control needs and estimated costs for providing these needs.

3. Suggest local and basin-wide pollution control measures which should be evaluated in planning a comprehensive water pollution control program for the Basin.

B. Acknowledgments

The cooperation and assistance of the following Federal, State, and local agencies are gratefully acknowledged:

U. S. Fish and Wildlife Service

U. S. Geological Survey

U. S. Army, Corps of Engineers, Norfolk District

U. S. Department of Commerce

Virginia Division of Industrial Planning and Development

Virginia Division of Water Resources

Virginia State Water Control Board

Virginia State Department of Health

Virginia Institute of Marine Science

Virginia Military Institute Research Laboratories

City of Richmond, Department of Public Works

II. GENERAL

A. Source of Information

Present water quality conditions covered in this report were evaluated by the staff of the Chesapeake Bay-Susquehanna River Basin Project, Federal Water Pollution Control Administration, employing the following sources of information:

1. Existing data obtained from files of Federal, State, and local agencies.
2. Results of stream sampling investigations conducted by State institutions under contractual agreements with the FWPCA.
3. Personal communications with municipal and industrial representatives associated with pollution abatement activities.

A biological study of the upper reaches of the James River and tributaries conducted by CB-SRBP comprised a special investigation to supplement sampling data of chemical and biochemical characteristics of water quality. Brief summaries of the biological studies are given, along with summaries of quality data, for most of the areas above Lynchburg, with more detailed descriptions of biological conditions outlined in the Appendix.

For evaluations of future water supply requirements, county population and industrial productivity projections developed by the National Planning Association were employed. The 1960 U. S. Census Report was used as a base from which individual

community projections were made. Industrial requirements were projected by type of industry on an individual production increase basis. Modifications were made to industrial projections when specific information was obtained regarding changes in processing, techniques, or plant operation.

B. Determination of Needs

Immediate water quality needs were evaluated in terms of treatment required to upgrade and maintain stream conditions which are generally recognized as being suitable for most beneficial uses; the minimum use being warm-water fishery. The effects of residual waste loadings to streams were evaluated with the degree of treatment specified which was expected to maintain the desired water quality for the immediate future. For the purpose of this report, the CB-SRBP has recommended, in most cases, that secondary treatment with 85 per cent removal of the biochemical oxygen demand of waste discharges be provided.

Cost estimates for new facilities and for upgrading present facilities to secondary treatment were calculated from construction cost information obtained from the literature[5] and updated, using Engineering News Record Current Cost Index. Existing estimates for proposed projects were obtained from some communities where engineering costs had been previously determined.

C. State Stream Classifications

At the writing of this report, the State of Virginia has not established specific water quality objectives for either

State-wide or individual stream application. It is anticipated, however, that stream standards will be adopted for the James River Basin in June 1967. The policy in the past has been to consider each waste discharged on its own merits, taking into consideration downstream water uses and assimilative capacity of the receiving waters. However, with certain modifications and/or expansion, the following basic criteria are used: (1) dissolved oxygen not lower than 4 milligrams per liter in the stream; (2) no appreciable settleable or floating solids; (3) no noticeable coloration or discoloration of the receiving stream; (4) toxic substance to be reduced below the toxicity of the stream; (5) no appreciable change of pH of the receiving stream; and (6) stream flow for design of sewage treatment facilities equal to minimum average 7-day low flow occurring in a 10-year frequency.

Proposed stream standards for the Basin have been prepared by the State Water Control Board and public hearings were held in April 1967. The standards generally follow the criteria used in the past with certain modifications applicable to specific reaches.

III. SUMMARY AND CONCLUSIONS

A. Findings

The James River Basin, an area of approximately 10,000 square miles, reflects a balanced economy that was established from the earliest colonial days. In addition to sanitary wastes, agriculture, chemicals, manufacturing, transportation, food processing and forestry all contribute to pollution loads discharged in the basin.

From its mouth at Hampton Roads upstream to Covington, a distance of 360 river miles, one-third of the James River is adversely affected by municipal and industrial wastes to the extent that use of its water is restricted to some degree. Biologically oxidizable wastes equivalent to a population of four million are produced each day in the basin. Present treatment and waste reduction practices reduce this amount to about two million population equivalents that are actually discharged to the James River and its tributaries. Table I summarizes municipal and industrial waste loadings discharged to various streams throughout the basin under present treatment levels and also indicates what these loadings would be if a secondary (85 per cent BOD removal) waste treatment policy were implemented.

The most critical areas, with regard to water quality, exhibit recurrent conditions of depleted or nearly depleted dissolved oxygen content. Industrial wastes resulting from pulp

and paper production account for a large part of the problem, especially in the Covington and Lynchburg areas. In all, industrial wastes account for about 50 per cent of the total organic waste load presently being discharged in the basin; municipal effluents account for the balance. Of the ten largest producers of organic waste in the basin including both municipal and industrial sources, only one provides secondary treatment to its waste.

Surface waters of the James River Basin are presently used for municipal and industrial water supply at a rate of 280 mgd. Municipal and industrial water use upstream from Richmond is now and will continue to be much less than the development potential of the surface water supply. Additional water supply impoundments may eventually become necessary for quality or convenience but this is not an immediate problem.

At Richmond and some of the communities along the Estuary, water supplies have reached or are approaching a critical stage. Development of water supply reservoirs in the basin will be a factor to be considered in any long term comprehensive water management study.

A comprehensive program to affect the proposed water quality standards (see Section II - C) throughout the Basin is beyond the scope of this study. The investigations and resultant recommendations of this study have been made to identify the most urgent needs of the basin that should be met to produce a significant improvement in stream water quality.

TABLE I

SUMMARY OF BIOCHEMICAL OXYGEN
DEMANDING WASTES IN THE JAMES RIVER BASIN
POPULATION EQUIVALENTS AT THE 1966 RATE OF DISCHARGE
AND AFTER 85 PER CENT BOD REMOVAL

Municipal Area	Present Rate			With 85% BOD Removal		
(Local Watershed)	Municipal	Industrial	Total	Municipal	Industrial	Total
	(Population Equivalents x 10^3)					
Covington-Clifton Forge (Jackson River)	15	50	65	4	51	59
Lexington-Buena Vista (Maury River)	11	38	49	3	23	26
Lynchburg (James River)	33	210	243	10	140	150
(Piney River)	--	NA*	--	--	NA*	--
Charlottesville (Rivanna River)	5	2	7	5	1	6
Richmond (James River)	370	71	441	79	11	90
(Chickahominy River)	2	--	2	2	--	2
Hopewell-Petersburg (James River)	120	610	730	39	150	189
Hampton Roads (James River)	430	35	465	96	13	109
Basin Total	986	1,016	2,002	238	389	631

* Approximately 68 tons/day of sulphuric acid is discharged to this stream.

B. Immediate Pollution Control Needs

1. Waste Treatment

The principal immediate need in the Basin is for the provision of adequate waste treatment facilities to control pollution at its source.

Immediate waste treatment needs and estimated costs for municipalities and industries in the Basin are given in Table II. A general summary of these needs follows:

a.	One municipality to provide primary and secondary treatment for existing untreated discharge.	$125,000
b.	One County Service Authority to provide sewerage system, including secondary treatment.	$1,400,000
c.	Sixteen municipalities to provide secondary treatment for existing primary discharges.	$34,795,000
d.	One Sanitary District Commission to continue with sewerage program, including secondary treatment facilities at four existing primary treatment plants.	$21,200,000
e.	Two Federal Installations to provide secondary treatment at existing primary treatment plants.	$1,050,000

f. Twelve industries to provide primary and secondary treatment of existing untreated discharges.	$20,750,000
g. One industry to provide enlarged secondary facilities and increased operating efficiency at existing secondary plant.	Cost undetermined
Total (excluding g)	$79,320,000

2. Flow Regulation

To adequately protect and enhance water quality in the face of population and industrial growth, urbanization, and technological change, water pollution control action, in addition to the provision of conventional waste treatment facilities, is needed in areas where stream flows are low in comparison to the existing and/or projected residual BOD loads which the stream must assimilate.

Reservoir storage to provide supplemental flow for water quality control is a possible solution to supplemental water pollution control needs in the two areas in the James River Basin where a need for greater than 85 per cent removal of the BOD in waste discharges is indicated.

The areas requiring flow regulation and proposed reservoirs are listed in Table III.

3. Special Studies

Additional investigations are needed in several areas in the Basin to provide the basis for comprehensive evaluations of existing or potential pollution control needs. Table IV summarizes these study needs.

4. Institutional Practices

A need for action on pollution control measures by various Federal, State, and local institutions in the James River Basin is indicated by the findings of this study. Table V summarizes needed institutional practices which would enhance and strengthen pollution control programs.

TABLE II

IMMEDIATE WASTE TREATMENT NEEDS

JAMES RIVER BASIN
(MUNICIPAL AND INDUSTRIAL)

Location	Responsibility	Need	Construction Cost	Total Annual Cost
Covington-Clifton Forge Area	1. West Virginia Pulp & Paper Company	1. Enlarge secondary to provide treatment for all waste discharges. 2. Improve STP efficiency.	Undetermined	
	2. Town of Covington	Secondary	$ 300,000	$ 20,000
	3. Town of Clifton Forge	Secondary	200,000	15,000
	4. Town of Low Moor	Primary and Secondary	125,000	10,000
	5. Town of Iron Gate	Secondary	30,000	2,000
	6. Town of Selma	Secondary	30,000	2,000
		TOTAL FOR AREA (excluding No. 1)	$ 685,000	$ 49,000
Lexington-Buena Vista Area	1. Town of Buena Vista	Secondary	$ 150,000	$ 10,000
	2. Town of Glasgow	Secondary	30,000	2,000
	3. Town of Lexington	Secondary	150,000	10,000
		TOTAL FOR AREA	$ 330,000	$ 22,000

TABLE II (Continued)

IMMEDIATE WASTE TREATMENT NEEDS

JAMES RIVER BASIN
(MUNICIPAL AND INDUSTRIAL)

Location	Responsibility	Need	Construction Cost	Total Annual Cost
Lynchburg Area	1. City of Lynchburg	Secondary	$ 1,750,000	$ 120,000
	2. Town of Madison Heights	Secondary	30,000	2,000
	3. Mead Corporation	Secondary or Equivalent	1,750,000(1)	120,000
	4. American Cyanamid	Discontinue acid discharges to Piney River	Cost undetermined	
		TOTAL FOR AREA	$ 3,530,000	$ 242,000
Charlottesville Area	1. Albemarle County Service Authority	Sewerage system, including secondary	$ 1,400,000	$ 105,000
		TOTAL FOR AREA	$ 1,400,000	$ 105,000
Richmond Area	1. City of Richmond	Expand sewerage Secondary	$20,000,000	$ 1,500,000
	2. Chesterfield County	Expand sewerage Secondary	4,000,000	290,000
	3. Henrico County	Expand sewerage Secondary	4,000,000	290,000
	4. Albemarle Paper Company (2)	Secondary or connect to municipal STP	1,225,000(1)	290,000
	5. Federal Paper Company (Southern)	Secondary or connect to municipal STP	150,000(1)	10,000
	6. Federal Paper Company (Seaboard)	Secondary or connect to municipal STP	200,000(1)	15,000

TABLE II (Continued)

IMMEDIATE WASTE TREATMENT NEEDS

JAMES RIVER BASIN
(MUNICIPAL AND INDUSTRIAL)

Location	Responsibility	Need	Construction Cost	Total Annual Cost
Richmond Area (continued)				
	7. Standard Paper Company	Secondary or connect to municipal STP	$ 700,000(1)	$ 50,000
	8. E. I. DuPont Company	Secondary or connect to municipal STP	4,500,000(1)	320,000
		TOTAL FOR AREA	$34,775,000	$2,475,000
Hopewell-Petersburg Area	1. City of Hopewell	Secondary	$ 800,000	$ 60,000
	2. City of Petersburg	Secondary	1,225,000	90,000
	3. City of Colonial Heights	Secondary	400,000	30,000
	4. Allied Chemical Company (Chemical)	Secondary or Equivalent	3,400,000	250,000
	5. Allied Chemical Company (Nitro)	Secondary or Equivalent	3,800,000	275,000
	6. Allied Chemical Company (Fibers)	Secondary or Equivalent	800,000	60,000
	7. Continental Can Company	Secondary or Equivalent	3,000,000	225,000
	8. Hercules Powder Company	Secondary or Equivalent	1,225,000	90,000
	9. Fort Lee Military Reservation	Secondary	350,000	25,000
		TOTAL FOR AREA	$15,000,000	$1,105,000

TABLE II(Continued)

IMMEDIATE WASTE TREATMENT NEEDS

JAMES RIVER BASIN
(MUNICIPAL AND INDUSTRIAL)

Location	Responsibility	Need	Construction Cost	Total Annual Cost
Hampton Roads Area	1. Hampton Roads Sanitation District	Implement Proposed Development Program	$ 14,000,000	$ 1,100,000
	a. Army Base Plant	Secondary	1,500,000	120,000
	b. Lambert Point Plant	Secondary	3,000,000	225,000
	c. Boat Harbor Plant	Secondary	2,500,000	175,000
	d. Patrick Henry Plant	Secondary	200,000	15,000
	2. City of Portsmouth	Secondary	1,700,000	125,000
	3. Fort Eustis Military Reservation	Secondary	700,000	50,000
		TOTAL FOR AREA	$ 23,600,000	$ 1,810,000
		TOTAL FOR BASIN	$ 79,320,000	$ 5,260,000

(1) Cost estimate based on separate treatment facility and municipal treatment plant costs.

(2) Richmond Plant scheduled to close in spring of 1967.

TABLE III

FLOW REGULATION FOR WATER QUALITY CONTROL

Location	Responsibility	Existing or Potential Need
Covington	Corps of Engineers (Gathright Project)	Jackson River - 67,000 acre-feet of storage to provide supplemental flow for water quality control.
Lynchburg	Corps of Engineers	Potential need for storage to provide supplemental flow for water quality control on the James River in the Lynchburg area.
Richmond	Corps of Engineers	Potential need for storage to provide supplemental flow for water quality control on the James River in the Richmond area.

TABLE IV

SPECIAL STUDIES NEEDED IN THE BASIN

Location	Responsibility	Need
Covington	Paper Industry	Color removal from paper wastes.
Lynchburg Area	Paper Industry	Color removal from paper wastes.
Charlottesville	City of Charlottesville and State of Virginia	1. Study relocation of STP outfalls from Moore's Creek to stream having a more dependable assimilation capacity. 2. Study nutrient enrichment problems in the Rivanna reservoir.
Hopewell	Local industries, City of Hopewell, and Fort Lee Military Reservation.	Study relocation of waste discharges from Bailey Creek to James River Channel.

TABLE IV (Continued)

Location	Responsibility	Need
Richmond	City of Richmond	Investigate purchase of Kanawha Canal water rights to prevent low flow diversion from James River Channel.
Basin-wide	FWPCA and State of Virginia	Develop basin-wide comprehensive study.
James Estuary	FWPCA and State of Virginia	Study nutrient enrichment problems in the estuary to evaluate control needs.
Richmond	City of Richmond	Investigate possible solutions to problems associated with the combined sewerage system.

TABLE V

INSTITUTIONAL PRACTICES NEEDED IN THE BASIN

Location	Responsibility	Need
Basin-wide	State of Virginia	Consider legislation to provide appropriations for State participation in grants for construction of sewage treatment works.
Basin-wide	State of Virginia	Legislation, if necessary, enabling approved surveillance of industrial waste loads.
Richmond Area	Local Government	Consider the establishment of a centralized water pollution control authority for the area.
Basin-wide	Local Government	Reduce infiltration problem by strengthening plumbing codes in house connections and emphasizing infiltration tests on new constructions.

IV. GENERAL BASIN DESCRIPTION

The James River Basin is narrow and irregular with headwaters in the Allegheny Mountains at the West Virginia State line, and the River flows generally southeasterly 340 miles through four physiographic regions : the Valley and Ridge, the Blue Ridge, the Piedmont, and the Coastal Plain. The total area drained is 10,060 square miles, of which 80 are in West Virginia at the edge of the Appalachian region. There is a total fall of 988 feet from the headwaters to the "Fall Line" separating the Piedmont and Coastal Plain at Richmond. From this point, the James is an estuary that joins the Chesapeake Bay at Hampton Roads.

Captain John Smith, in describing the James River Basin, wrote: "Heaven and earth never agreed better to frame a place for man's habitation." The observation is appropriate. The Area has a mild climate, without extremes in temperature, and there is adequate, well-distributed rainfall to encourage agricultural development of the rich soil. Preceding the colonists, the Indians developed a successful though primitive agriculture. As the colonists increased, European farming methods were adapted to the new plant species; tobacco was introduced to the Old World, and agricultural development spread first in the Coastal Plain and then to the Piedmont. To this date agriculture remains a primary activity of the Area.

Industry also dates back to colonial times. The forest resources provided lumber as well as charcoal for making iron from the native ore, and eventually pulp for paper making which is now one of the largest industries in the State. The extensive chemical industry existing in the Basin today had its beginnings in the manufacture of indigo, tannin, tars, and turpentine.

Transportation by water opened the land, first to the head of the Estuary at Richmond and, later, with development of The Kanawha Canal system to beyond the Blue Ridge. Highways and railroads facilitated the movement of population to major communities at Petersburg, Lynchburg, Charlottesville, and Covington. The estuarine area offered the convenience of deep water shipping to Hopewell, Newport News, Portsmouth, and Norfolk.

As population increased in the developing communities, public sewer systems were constructed, many being designed to convey both storm and sanitary wastes, and the James River became the recipient of untreated discharges from several population centers in the Basin. Consequently, the River essentially became, in several reaches, an open sewer with water quality becoming increasingly less suitable for most beneficial uses. With the enactment of the Virginia Water Control Law in 1946, pollution control programs were formulated, and the arduous task of abating pollution in the James River began. Much progress has been made, but the ravages of the past are still evident. The sewage from

populated areas is generally treated, but not as completely as desirable, and the industrial waste discharges fall far short of the treatment required to restore the quality of waters to a level acceptable for most beneficial uses.

An analysis of the Basin by areas discharging significant waste loads to local watersheds will serve to identify the problems, suggest corrective actions, and estimate costs for needed actions.

V. WATER POLLUTION PROBLEMS, NEEDS AND COSTS

A. The Covington-Clifton Forge Area

1. Jackson River Watershed

a. Pertinent Hydrologic Characteristics

The Jackson River joins with the Cowpasture River approximately 22 miles below Covington to form the James River. This section of the Jackson River is shallow, rocky-bottomed and contains alternating stretches of riffles and pools. During the dry season nearly all of the base flow in the river is provided by springs, most of which are upstream from Covington. The drainage area to the head of the reach at Covington below Dunlop Creek is 610 square miles. The flow through the reach has been assumed equal to the summation of the flows at the Falling Spring gage on the Jackson River (DA = 409 square miles) and the Dunlop Creek gage near Covington (DA = 166 square miles). During the dry season very little, if any, flow is added to the reach downstream from these two gages.

The minimum daily flow recorded at the Falling Spring gage is 57 cfs, and the average discharge for the period of record is 480 cfs. The minimum and average daily discharges recorded at the Dunlop Creek gage are 9 cfs and 157 cfs, respectively.

The U. S. Army Corps of Engineers' Gathright Project is located on the Jackson River above Covington. Plans for this

project, expected to be completed in the early 1970's, include provisions for 60,700 acre feet of storage for water quality control.

b. Current Water Quality

The Jackson River below Covington is annually afflicted with depressed dissolved oxygen conditions during the dry summer months. Table VI is a summary of dissolved oxygen measurements made during a one-week intensive survey in July of 1966. These low dissolved oxygen conditions are the result of heavy organic loadings to the stream at Covington.

TABLE VI

SUMMARY OF DO DATA COLLECTED DURING 1966 INTENSIVE SURVEY
ON THE JACKSON RIVER BELOW COVINGTON, VIRGINIA
July 10-16, 1966

STATION LOCATION	NUMBER OF SAMPLES	AVERAGE DO mg/l	MINIMUM DO mg/l	MAXIMUM DO mg/l
Covington Filter Plant	34	7.1	5.9	9.1
VEPCO Substation	34	0.3	0.0	1.2
Fudge's Bridge	15	0.4	0.1	0.6
Hercules Plant Bridge	5	0.7	0.1	1.1
Route 18 Bridge	34	0.4	0.1	0.6
Low Moor Bridge	34	1.2	0.2	2.9
Old Boat Landing	29	1.9	0.1	4.3
Swinging Bridge	19	2.4	0.1	4.3
Route 60 Bridge	34	2.6	0.2	4.4
Iron Gate Bridge	34	3.9	0.8	5.6

A biological survey made during the summer of 1966 shows pollution tolerant organisms to be dominant among the bottom fauna for the sections of the Jackson River between Covington and Clifton Forge. Appendix A is a complete report of that survey.

A review of survey data from past studies by other investigators indicates that quality problems have existed in this area during low stream flows for a number of years. A survey and report made by the U. S. Public Health Service to the Army Corps of Engineers in 1945, shows water quality conditions to have been nearly the same as were found during the 1966 survey, even though considerable pollution abatement measures have been taken.

c. Major Sources of Waste and Present Pollution Abatement Practices

Table VII lists the major waste contributors, their present load and type of treatment. West Virginia Pulp and Paper Company, at Covington, is seen to be the largest producer of biologically degradable waste, and even though this company maintains a secondary treatment plant, the discharged waste load represents about 75 per cent of the present total load to the stream in the area. The Towns of Covington, Clifton Forge, Iron Gate, and Selma provide primary treatment for their municipal wastes and Low Moor presently discharges its waste untreated into Karnes Creek, a tributary to the Jackson River.

Although the West Virginia Pulp and Paper Company waste treatment plant operates at an average annual efficiency of 85 per cent removal or better, the variability of treatment efficiency is apparently large, resulting in a considerably increased load to the stream on occasion. During the summer months treatment variability may be critical, and some provision is needed to assure a more uniform efficiency. Subsequent analyses in this report are based upon the assumption of uniform treatment efficiency for this and all other waste discharges. Approximately one-fourth of the load discharged by the industry does not receive treatment.

A somewhat unusual condition exists in this section of the river during low stream flows when the West Virginia Pulp and Paper Company effluent comprises more than half of the available Jackson River flow. The resulting mixture of waste and river flow produces an immediate low DO water due to the lack of oxygen in the waste effluent. Efforts have been made by the industry to aerate the river by using instream mechanical aerators.

TABLE VII

PRINCIPAL WASTE DISCHARGES
IN THE COVINGTON-CLIFTON FORGE AREA

Location	Type of Waste	Type of Efficiency of Waste Removal	Waste Load Discharged P E
Covington	Municipal	Primary	8,500
Clifton Forge	Municipal	Primary	5,000
Low Moor	Municipal	None	600
Iron Gate	Municipal	Primary	600
Selma	Municipal	Primary	700
West Virginia Pulp and Paper Company	Industrial	Secondary	50,000
Total for Water Service Area			65,400

d. Recommended Immediate Pollution Control Needs

The provision of storage for water quality control in the proposed Gathright Reservoir was computed on the basis of a minimum of secondary treatment, or its equivalent in BOD removal by all waste contributors. The largest waste contributor, the West Virginia Pulp and Paper Company, is presently providing secondary treatment to approximately 96 per cent of its total waste flows. Additional capacity to treat the remaining 4 per cent, which represents one-fourth of the total load discharged to the river by the Company, is recommended. In addition to increasing the treatment capability to handle all of the waste

produced by the paper company, some provision should be made to reduce the variability in waste load discharged to the stream during the critical months. The municipalities and communities in the area (see Table VII) should increase their waste removal facilities to provide secondary treatment either individually or in a centralized treatment unit.

The U. S. Army Corps of Engineers' Gathright Project, for which construction approval has been granted, should be expedited. This reservoir will provide 60,700 acre feet of storage for water quality control. The annual cost allocated to water quality control by this project is estimated to be $75,000.

Cost for increasing treatment in the area to 85 per cent BOD removal is estimated to be $55,000 per year for a total cost, including flow augmentation, of $130,000 per year to satisfy immediate pollution control requirements in the Covington-Clifton Forge area.

Because of the large volume of waste relative to the low stream flows, it is further recommended that no waste be discharged to the river with a DO of less than 2.0 mg/l.

e. Water Supply Needs

Table VIII shows the present and projected water supply requirements for the Covington-Clifton Forge area through 2020. The bulk of both the present and projected needs are for industrial purposes. Nearly all of the 38.9 mgd presently being

used is from surface water supplies, primarily the Jackson River. The City of Covington obtains its municipal water from a Jackson River intake at Clearwater Park. Below this intake at Covington, the West Virginia Pulp and Paper Company withdraws an average of 35 mgd from the Jackson River for industrial use. The water requirements projected for 1980 and 2020 exceed minimum Jackson River flows; however, all of these needs are primarily for a single industrial use. Any plan to develop additional water supply capacity must allow for changes to consider industrial processes that may make drastic changes in the water requirements for that industry.

TABLE VIII

PRESENT AND PROJECTED WATER SUPPLY REQUIREMENTS
FOR THE COVINGTON-CLIFTON FORGE AREA

	Average Daily Demand (mgd)		
	1965	1980	2020
Municipal	3.3	3.4	4.6
Industrial	35.6	68.3	80.0
TOTAL	38.9	72	85

B. Lexington-Buena Vista Area

1. Maury River Watershed

a. Pertinent Hydrologic Characteristics

The Maury River enters the James River at Glasgow, Virginia, (River Mile 279.8) and drains a watershed of approximately

700 square miles. The U. S. G. S. gaging station near Buena Vista on this river drains 649 square miles. The average and minimum daily discharges at the gage are 640 cfs and 50 cfs, respectively.

b. Present Water Quality

The U. S. Fish and Wildlife Service reports (see Appendix B) that frequent light fish kills occur in the Maury River between its mouth and Buena Vista, approximately 12.5 miles upstream. At the time of this report, no chemical data was available from which to ascertain the cause of these kills; however, large organic waste loads, primarily of industrial origin, are discharged to the stream in this area, and it is reasonable to assume that low dissolved oxygen content is at least partially responsible.

c. Major Sources of Waste and Present Pollution Abatement Practices

As far as can be determined from the limited available data, approximately three-fourths of the organic waste discharged to the Maury River in this area originates from an industrial wool scouring process (James Lee & Sons) at Glasgow, Virginia, where the Maury River merges with the James. This and other industrial and municipal waste discharges in the area are listed in Table IX together with an estimate of their respective waste loads. Total population equivalents discharged to local water courses is approximately 49,000.

TABLE IX

PRINCIPAL WASTE DISCHARGES
IN THE LEXINGTON-BUENA VISTA AREA

Location	Type of Waste	Type or Efficiency of Waste Removal	Waste Load Discharged P E
Buena Vista	Municipal	Primary	4,600
Glasgow	Municipal	Primary	900
Lexington	Municipal	Primary	5,300
James Lee & Sons	Sanitary	Secondary	200
James Lee & Sons	Industrial	Acid cracked and Lagooned	38,000
Bonded Fibers	Industrial	None	200
Total for Water Service Area			49,200

d. Recommended Immediate Pollution Control Needs

To meet the minimum treatment requirements recommended in this report, all waste contributors must expand their present waste removal facilities to provide secondary treatment or equivalent. This can be done at an estimated total cost of $45,000 (per year).

Due to high dilution provided by the Maury River and the fact that the area population is relatively stable (see Appendix C), secondary treatment or its equivalent will probably resolve the stream quality problems in this area.

e. Water Supply Needs

Table X gives a breakdown of present and projected water supply needs in this water service area which includes the towns of Buena Vista, Lexington, and Glasgow. The total area population is not expected to increase appreciably in the next 50 years, but industrial activity is expected to almost double industrial water supply demands.

The sources of municipal supply presently total about 2 mgd and are primarily ground water and upstream reservoirs, with the Maury River itself an auxiliary supply. The Reeves Brothers Vulcan Plant in Buena Vista accounts for 10.9 mgd of the present 13.6 mgd industrial water usage. All but approximately 3.0 mgd of the total is for cooling purposes.

For the water service area, about 13 mgd of the present water usage of 15.6 mgd is obtained from ground water sources.

The year 2020 projected water requirement of 28 mgd is less than the minimum unqualified flow of 30 mgd recorded for the Maury River at Buena Vista.

No additional water supply developments are needed for this water service area except as may be locally desired from a quality or convenience standpoint.

TABLE X

PRESENT AND PROJECTED WATER SUPPLY REQUIREMENTS
FOR THE LEXINGTON-BUENA VISTA AREA

	Average Daily Demand (mgd)		
	1965	1980	2020
Municipal	2.0	3.1	3.6
Industrial	13.6	24.0	24
TOTAL	15.6	27.1	27.6

C. Lynchburg Area

1. James River Watershed

a. Pertinent Hydrologic Characteristics

The James River between Big Island and Bent Creek, some 47 miles of stream, averages approximately 7 feet in depth under summer flow conditions. The river emerges from the Blue Ridge Mountains on the Piedmont physiographic province, and a somewhat more uniform river bed and channel gradient is found. The river flow is regulated to meet peak power loads at several run-of-the-river dams upstream from Lynchburg. The Army Corps of Engineers' Gathright Project on the upper Jackson River, when completed in the early 1970's, will provide 60,700 acre-feet of storage for low flow augmentation.

Stream flow in this section of the James River has been referenced to the U. S. G. S. gaging station at Holcombs Rock. The drainage area above the gage is 3,250 square miles, and the mean and minimum daily flows recorded are 3,492 and 223 cfs, respectively.

b. Present Water Quality

Table XI summarizes the dissolved oxygen data collected during the 1966 intensive survey of the James River. These data, supported by past studies of other investigators, evidence recurrent water quality problems in this section of the James River. During low flow conditions, two dissolved oxygen sags are seen to occur in the river; one between Big Island and Lynchburg and the other below Lynchburg. Occasional light fish kills have been observed below Lynchburg and complaints have been made by the local citizens that the fish caught in this area have a bad taste.

A biological study of this section of the river (see Appendix A) shows evidence of moderate to heavy degradation. The U. S. Fish and Wildlife Service reports (see Appendix A) that approximately 7 miles of the James River in this area is adversely affected by municipal and industrial pollution.

TABLE XI

SUMMARY OF D O DATA COLLECTED DURING 1966 INTENSIVE SURVEY ON THE JAMES RIVER BELOW BIG ISLAND, VIRGINIA

Station Location	Number of Samples	Average D O mg/l	Minimum D O mg/l	Maximum D O mg/l
Parkway Bridge	34	6.4	5.7	7.1
Skimmer Creek	34	4.4	2.5	5.9
Coleman Falls West	34	3.6	1.8	6.0
Coleman Falls East	34	6.0	5.1	6.9
Holcomb Rock	34	7.2	6.0	7.6
Lynchburg	34	6.6	4.7	11.5
Six Mile Bridge	34	2.0	0.6	4.1
Galtz Mill	34	2.5	1.3	3.7
Stapleton	34	2.9	0.9	4.6
Eades' Laundry	34	3.3	1.5	4.8
Riverville	34	4.7	2.9	6.9
Allen's Creek	34	5.3	3.4	6.9

c. Major Sources of Waste and Present Pollution Abatement Practices

Organic wastes resulting from pulp and paper production along with municipal wastes constitute the major sources of oxygen demanding waste discharged to the James River in this area. Table XII lists the major contributors, their present loads, and type of treatment. Under present treatment practices, a total of 246,000 population equivalents of biologically degradable

waste is discharged daily into the local watercourses. About 85 per cent of this load is of an industrial origin. None of the principal waste contributors presently provides secondary waste treatment or its equivalent in removal of oxygen demanding wastes with the exception of the Owens-Illinois Paper Plant located on the James at Big Island, Virginia. This plant has reduced its losses to the river by approximately 85 per cent through process changes. The Mead Corporation, another large paper plant located in Lynchburg, Virginia, has also reduced its losses by about 65 per cent through process changes. The City of Lynchburg has a conventional primary treatment plant for its municipal wastes.

TABLE XII

PRINCIPAL WASTE DISCHARGES
IN THE LYNCHBURG AREA

Location	Type of Waste	Type or Efficiency of Waste Removal	Waste Load Discharged P E
Lynchburg	Municipal	Primary	32,400
Madison Heights	Municipal	Primary	1,000
Lynchburg Rendering	Industrial	20%	1,000
Mead Corporation	Industrial	In Process (65%)	124,000
Owens-Illinois	Industrial	In Process (85%)	89,000
Total for Water Service Area			246,000

d. Recommended Immediate Pollution Control Needs

The reduction of all wastes by secondary treatment or equivalent BOD removal is recommended as the most urgent pollution control need for this important area. The resultant waste load from these actions would be 40 per cent less than the load presently being discharged and the dissolved oxygen at the critical point below Lynchburg would improve from 2.0 mg/l average measured during the 1966 survey to 5 mg/l under the same flow and temperature conditions.

The estimated total cost for the area to meet this minimum treatment requirement is $230,000 per year.

The completion of Gathright Reservoir on the upper Jackson River will permit increase in dry season river flows and thereby reduce the severity and frequency of critically low dissolved oxygen conditions.

e. Water Supply Needs

Municipal and industrial water supply requirements presently total approximately 30 mgd for the Lynchburg area. All but about 0.2 mgd of this supply is met from surface water sources and about 20 mgd is for industrial uses. The Owens-Illinois Paper Company at Big Island, upstream from Lynchburg on the James, and the Mead Corporation, also a paper plant, are the largest industrial users in the area. Both companies obtain their water from the James River and Mead's intake is located downstream from the point of discharge of Owens-Illinois waste water.

The City of Lynchburg maintains a water supply reservoir on the Pedlar River, a tributary of the James, and has an auxiliary capability on the James River itself.

Water supply needs for the area are projected to increase to 88 mgd by the year 2020. Table XIII is a breakdown of projected requirements for municipal and industrial use.

The projected total requirement for the year 2020 is well below the minimum James River flow of record as recorded at the Holcomb's Rock gage. The minimum flow at this gage was about 150 mgd compared to the total projected water supply requirement of 88 mgd.

No additional water supply development is indicated for this area.

TABLE XIII

PRESENT AND PROJECTED WATER SUPPLY REQUIREMENTS
FOR THE LYNCHBURG AREA

	Average Daily Demand (mgd)		
	1965	1980	2020
Municipal	10	18	61
Industrial	20	30	27
TOTAL	30	48	88

2. Buffalo River Watershed

a. Pertinent Hydrologic Characteristics

The Buffalo River flows southeast out of Amherst County and joins the James River at Norwood in Nelson County. The river drains a watershed of 360 square miles and the critical 7-day drought discharge is approximately 0.094 cfs per square mile. The mean discharge at Norwood is 474 cfs.

The principal tributary of the Buffalo River is the Tye River which joins the Buffalo River approximately 5 miles above Norwood. Piney River, a tributary of the Tye River, drains a watershed of approximately 50 square miles and contributes a mean flow of 87 cfs.

b. Present Water Quality

Chemical water quality surveys of the Buffalo River and tributaries were not conducted by the CB-SRBP for this report, but reports of investigations by other agencies (see Appendix B) indicate that Piney River is grossly polluted with acid wastes. Fishing resources are totally eliminated in the stream, and the acid wastes contributed by Piney River affects water quality downstream to the confluence of the Buffalo and James Rivers. The pH in Buffalo River at Norwood averages 3.5 . A recording pH meter at Wingina, operated by the American Cyanamid Company, indicates pH levels range from 6 to 7 in the James River below the mouth of the Buffalo River.

c. Major Sources of Waste and Present Pollution Abatement Practices

The source of the acid waste discharge to Piney River is an American Cyanamid Company plant located seventeen river miles above Norwood. The plant produces titanium dioxide from locally mined titanium, using sulfuric acid, and the diluted used acid is discharged to the river. The average discharge to the river is about 68 tons of acid per day.

d. Recommended Immediate Pollution Control Needs

To enhance and protect the water quality of streams in the Buffalo River watershed and to reduce the possibility of contributing damaging acid wastes to the James River, the American Cyanamid Company should take necessary action to alleviate the acid waste problem in Piney River.

Neutralization or acid reclamation processes should be employed as required to reduce acid discharges to levels which will not adversely affect water quality in the watershed.

D. Charlottesville Area

1. Rivanna River Watershed

a. Pertinent Hydrologic and Physical Characteristics

The Rivanna River drains a watershed of approximately 700 square miles, 500 of which lie above the Charlottesville Area. The average and minimum daily discharges recorded at the U.S.G.S. gaging station at Palmyra (DA = 617 square miles) are 681 cfs

and 11 cfs, respectively. At Charlottesville, the several streams draining the eastern front of the Blue Ridge Mountains converge to form a relatively mature river as the Rivanna flows out onto the Piedmont Plateau and then to the James River some 35 river miles downstream from Charlottesville.

b. Present Water Quality

Chemical water quality surveys were not conducted in the Charlottesville Area for this report. Biological observations, however, have been made by the U. S. Fish and Wildlife Service, and a report from that agency (see Appendix B) reveals problems with regard to the fish population in three reaches of the Rivanna and its tributaries. The main stem of the Rivanna River in the Charlottesville vicinity is shown to suffer light losses in potential fish population. Moores Creek is unable to support a fish population and the Mechum River, for almost ten miles above its confluence with the South Fork of the Rivanna, is reported to be severely affected.

c. Major Sources of Waste and Present Pollution Abatement Practices

All of the foregoing water quality problems are the result of municipal and industrial waste discharges. The major contributors are: the City of Charlottesville, affecting the Moores Creek and Rivanna River reaches, and Morton's Frozen Food Corporation in the Crozet Area, affecting the Mechum River reach. The City of Charlottesville presently operates two secondary treatment plants

designed to serve a total population of approximately 43,000. Both plants discharge their effluents to small tributaries (Moores Creek and Meadow Creek) which flow into the main stream of the Rivanna River.

Morton's discharges its food processing waste into a small tributary of the Mechum River after treatment by an activated sludge plant which was placed in operation in November 1966. Waste from this industry has been the primary source of pollution in the Mechum River for a number of years. This recent pollution abatement action is expected to effect considerable improvement in river water quality.

The Albemarle County Service Authority operates several lagoons in county residential areas, and plans for a sewerage system for the west central county area have been made. The system, including a secondary treatment plant, would intercept sanitary and industrial wastes emanating from the Crozet Area.

d. Recommended Immediate Pollution Control Needs

Charlottesville's two waste treatment plants discharge to small tributaries (Meadow Creek and Moores Creek) which, during the dry season, provide little or no flow for dilution of the effluent. Without detailed study, the indicated solution to achievement of the water quality objectives in these tributaries is to pipe the effluent to the nearest receiving water having a higher and more dependable assimilative capacity. An

alternative to changing the outfall location would be to provide advanced waste treatment. However, cost estimates of these two alternatives have not been made. A comprehensive study of the James River Basin should consider these and other alternatives for achieving specific water quality objectives in this area.

The Albemarle County Service Authority Crozet Project would enhance development in the Crozet Area and also provide additional capacity for treatment of industrial wastes, including Morton's Frozen Foods discharges if required. The estimated cost of the proposed Crozet project is $1,400,000.

e. Water Supply Needs

Several small water supply reservoirs provide raw water storage for the City of Charlottesville, the largest water user in the water service area, which has an average daily use varying from 4.7 to 6.2 mgd. An auxiliary intake is located on the Mechum River and a new 1.76 billion gallon raw water reservoir has been constructed on the South Fork of the Rivanna River. Adequate surface water supplies are available to meet the projected water supply needs through the year 2020. Table XIV shows the projected water supply requirements for the Charlottesville water service area.

TABLE XIV

PRESENT AND PROJECTED WATER SUPPLY REQUIREMENTS

FOR THE CHARLOTTESVILLE AREA

	Average Daily Demand		
	1965	1980	2020
Municipal	4.8	8.9	14
Industrial	0.5	1.0	2
TOTAL	5.3	10	16

E. Richmond Area

1. James River Watershed

a. Pertinent Hydrologic Characteristics

At Richmond, the James River flows across the Fall Line, which delineates the eastern edge of the Piedmont physiographic province, and onto the Coastal Plain. As a consequence, the James River falls approximately 75 feet in 6 miles at Richmond and below Richmond becomes a tidal estuary.

Above Richmond, at Bosher Dam, the Kanawha Canal diverts a portion of the James River flow from the main channel and returns it to the river at tidewater. The U. S. G. S. maintains gaging stations on both the Canal and the river. The mean and minimum combined flows at both gages, which is estimated to be the flow to the estuary, is 7,351 cfs and 350 cfs, respectively.

During drought conditions such as have occurred during recent years, all of the river flow is sometimes diverted into the Kanawha Canal at Bosher Dam, producing conditions of little or no flow in the main river channel between the diversion dam and tidewater. The diverted flows are utilized by the City of Richmond and local industrial concerns which own water rights in the Canal (see paragraph e.).

b. Present Water Quality

The water quality of the James River below Richmond is adversely affected by waste discharges from the Richmond Area during the hot, dry summer months to the extent that the river is unfit for most beneficial uses. Dissolved oxygen concentrations are frequently less than 1 mg/l, fish kills occur, and gasifying sludge deposits float to the surface during warm low flow periods. Table XV summarizes some dissolved oxygen analyses made by the City of Richmond in the tidal James.

The Boulevard Bridge Station is located upstream from most waste discharges in the Fall Zone and the terminal station is upstream from the city's sewage treatment plant. Although the river is seen to be recovering at the Dutch Gap station, which is about 12 miles below the sewage treatment plant, the appearance of the river seriously limits its recreational and aesthetic use downstream to the Hopewell Area. Eutrophication processes accelerated by nutrient enrichment from municipal and industrial wastes are among the contributing factors of this

degradation. The extent of this eutrophication and possible decelerating actions will be examined in a FWPCA comprehensive project report scheduled for a later date.

TABLE XV

SUMMARY OF DO DATA COLLECTED
BY CITY OF RICHMOND DURING JULY AND AUGUST 1966

STATION LOCATION	NUMBER OF SAMPLES	AVERAGE DO mg/l	MINIMUM DO mg/l	MAXIMUM DO mg/l
Boulevard Bridge	10	7.1	5.1	8.2
Intermediate Terminal	10	1.9	0	4.9
Light 168	10	.4	0	2.5
DuPont Intake	10	.9	0	3.7
Light 166	10	.8	0	4.9
Dutch Gap	3	3.5	1.7	4.9

Above the head of tidewater, in that section of the river below the Canal diversion, low flow conditions result in near stagnant pools which become nutrient enriched from urban run-off and combined sewer discharges. This enrichment, in turn, promotes the growth of phyto-plankton and algal blooms often occur. Thus, the major part of the river within the city is rendered unfit for any use and is a potential health hazard under low flow conditions.

Attesting to the seriousness of the problem is the current awareness and concern being expressed by both public and civic leaders in the Richmond area.

c. Major Sources of Waste and Pollution Abatement Practices

Both municipal and industrial wastes contribute to the problem at Richmond. Several industries discharge their waste to the city sewerage system and are treated at the city's primary waste treatment plant. A few significantly large industrial wastes are discharged directly to the local watercourses. Table XVI is a list of the principal waste discharges in the area, their present treatment, and waste effluent loads. The City of Richmond's current plans call for the provision of secondary treatment of all municipal wastes, including certain areas in Henrico County, by the early 1970's. At present the city provides primary treatment for 70 per cent of its sewered waste. The remaining 30 per cent discharges untreated to the James River through several combined sewers. Henrico County presently provides secondary treatment for all county waste discharges, except for areas in the west and northwest sections of the county which are under contractural arrangements with the City or Richmond and discharge to the city interceptors. Chesterfield County has recently completed a $9,000,000 sewerage system which includes a 3 mgd primary treatment plant. Both Henrico and Chesterfield have expansion programs underway which

will provide sewage collection and secondary treatment for rapidly developing county areas.

A total organic waste loading of about 435,000 population equivalents per day is applied to local watercourses in this area. Of this total, 350,000 PE's originate from Richmond municipal sources. Secondary waste treatment for all of Richmond's municipal waste would reduce the Richmond contribution to about 72,000 PE's per day.

TABLE XVI

PRINCIPAL WASTE DISCHARGES

IN THE RICHMOND AREA

Location	Type of Waste	Type or Efficiency of Waste Removal	Waste Load Discharged P E
Richmond (James River)	Municipal	Primary	236,000
Untreated Richmond Load (James River)	Municipal	None	115,000
Chesterfield (James River)	Municipal	Primary	13,000
Crestview Apartments (Chickahominy Watershed)	Municipal	Secondary	100
Henrico County (Chickahominy Watershed)	Municipal	Secondary	100
Henrico County (Chickahominy Watershed)	Municipal	Secondary	1,450
Hechler Village (James River)	Municipal	Secondary	500
Byrd Airport (Chickahominy Watershed)	Municipal	Secondary	450
Albemarle Paper Co.* (James River)	Industrial	In Process (20%)	2,300
Federal Paper Co. (Southern) (James River)	Industrial	In Process (20%)	5,200
Federal Paper Co. (Seaboard) (James River)	Industrial	In Process (20%)	8,800
Standard Paper Co. (James River)	Industrial	In Process (20%)	2,000
E. I. duPont Co. (James River)	Industrial	None	50,000
Total for Water Service Area			434,900

* Scheduled to close in spring 1967.

d. Recommended Immediate Pollution Control Needs

In the Richmond area the most urgent requirement to improve James River water quality is secondary treatment of Richmond municipal wastes. The city's plans call for completion of a secondary waste treatment plant capable of handling all of the municipal wastes by 1971. Expedition of these plans is urgently recommended to improve the extremely poor conditions in the James at and below Richmond. The city has estimated that a total capital cost of $15,000,000 is necessary for completion of the planned program. In terms of annual cost based on a 20 year period of amortization at 4½ per cent interest and adding an estimate for operation and maintenance, the total annual cost would be about $2,000,000 for the city. About $600,000 per year would be required to treat all other wastes in the area to the level of 85 per cent BOD removal.

Completion of the Richmond interceptors and the secondary treatment plant should be accomplished at the earliest possible date. This is, perhaps, the most urgent need in the entire river basin. In addition, engineering studies should be initiated and plans formulated for delivering secondary treatment or equivalent BOD removal to all waste discharges in the area. The total annual cost for attaining this secondary treatment objective is estimated to be $2,600,000.

Since eutrophication of the estuary has caused serious water quality problems, some nutrient removal by the waste treatment plants will be necessary in the future. Studies are now being made to determine nutrient removal requirements and costs. Therefore, in waste treatment plant design, space should be provided for possible future nutrient removal.

Also urgently needed in the City of Richmond is the capability of alleviating the pollution problems resulting directly or indirectly from combined sewers in the City of Richmond. Raw sewage discharges during storm flow conditions contribute significantly to the pollution of the river, and operational problems at the municipal treatment plant created by sand and gravel washed into the plant during storm flows also lower treatment plant efficiency. Studies should be made of alternative methods of reducing pollution problems related to the combined sewers.

e. Water Supply

The present municipal and industrial water supply use in the Richmond area averages about 52 mgd exclusive of that used for power production. Many industrial and commercial water supplies are purchased from the City of Richmond. As shown in Table XVII, the total requirement is projected to more than triple by the year 2020. Almost all of the large supplies are obtained from the James River, which has a minimum flow at Richmond of 350 cfs (226 mgd).

When evaluating water usage and future water supply needs at Richmond, the water rights for 645 cfs of James River flow must be considered. These water rights are deeded to the Chesapeake and Ohio Railway Company, then leased by them to others on a long-term basis and apportioned as follows:

City of Richmond	88
VEPCO	173
Albemarle Paper Company	384
	645 cfs

During periods of summer low flow, water rights almost equal stream flow. The City of Richmond has negotiated an agreement with VEPCO, giving Richmond use of VEPCO's 173 cfs for municipal supply during periods of low flow when James River flow would not meet the City's needs. This 173 cfs is restricted to municipal water supply only. Combined City and VEPCO rights amount to 261 cfs (167 mgd) which is less than the projected 2020 requirement of 180 mgd (see Table XVII).

The completion of Gathright Reservoir on the upper Jackson River is expected to increase the low summer flows in the James by about 200 cfs. Although this low flow augmentation was designed for water quality control on the Jackson River, it will undoubtedly benefit the Richmond area water supply by increasing the extreme low flows. A water supply reservoir has been approved for the

Appomattox River above Petersburg which will be a potential future water supply source for Richmond. This 11.5 billion gallon development is so located as to provide a potential supply for all water users in the lower James River Basin. A detailed engineering study for this development has been proposed by the Appomattox River Development Committee.

TABLE XVII

PRESENT AND PROJECTED WATER SUPPLY REQUIREMENTS FOR THE RICHMOND AREA

	Average Daily Demand		
	1965	1980	2020
Municipal	36	70	130
Industrial	16	20	50
Total for Water Service Area	52	90	180

2. Chickahominy River Watershed

a. Pertinent Hydrologic Characteristics

The Chickahominy River, draining a watershed of approximately 400 square miles, has head waters in Henrico and Hanover Counties and discharges to the James approximately seven miles above Jamestown. The mean flow near Providence Forge is 271 cfs. The north side of the City of Richmond, and approximately half of Henrico County, is drained by tributaries of the Chickahominy River.

b. Present Water Quality

The water quality of Upham Creek, a tributary of the Chickahominy River which receives urban run-off from the City of Richmond and waste discharges from Henrico County secondary waste treatment plants, is adversely affected by organic wastes. Recent dissolved oxygen data on the Creek is not available, but a report by the U. S. Fish and Wildlife Service (Appendix B) states that fishery resources are severely affected by pollution.

Data on the Chickahominy River below Richmond indicates significant improvement in dissolved oxygen concentrations in the River since the early 1960's when flow from two treatment plants, one belonging to the City and one County-owned, were abandoned and waste flows were pumped to Richmond sewers in the James River Watershed. Results of analysis made in the summer months of 1964 indicated dissolved oxygen concentrations ranging from 4.2 to 9.0 .

c. Major Sources of Waste and Pollution Abatement Practices

The principal waste discharges to the Chickahominy River Watershed are from secondary waste treatment plants owned by Henrico County, private developments, and Richmond's Byrd Airport secondary plant. (See Table XVI). Urban run-off from the City of Richmond also contributes to the pollution problem and some raw sewage from City sewers flows into Upham Creek when sanitary sewers become surcharged by storm water infiltration.

The master plan for Henrico County's water pollution control program includes interceptor and pumping station facilities which would intercept and pump all county waste discharges in the Chickahominy Watershed to sewerage systems in the James River Watershed.

d. Recommended Immediate Pollution Control Needs

The current Henrico County pollution control program in the Chickahominy River Watershed should be continued. This program is designed to provide sewerage systems for the urbanized areas without increasing waste load discharges to the Watershed. New sewer systems flow to pumping stations which pump waste flows to the City of Richmond sewerage system. Plans are also being made to reduce the present flow to the Sandston treatment plant, which discharges to a tributary of the Chickahominy River, by pumping a portion of the flow to the James River Watershed for treatment. Costs for these improvements are included in this report under Richmond Area - James River Watershed.

The Henrico County master plan for pollution control would provide the capability for eliminating all county waste discharges to the Chickahominy Watershed by pumping all flow to James River sewerage systems. The estimated cost for the program, which also includes current and future County projects in the James River Watershed, is $17,000,000.

The existence of two watersheds (James and Chickahominy) and three separately administered pollution control programs (City of Richmond, Henrico County, and Chesterfield County) in the Richmond Area suggests the need for a comprehensive pollution control study of the Richmond Area with the formation of a water pollution control authority as a possible goal.

F. Hopewell-Petersburg Area

1. James River Watershed

a. Pertinent Hydrologic Characteristics

Hopewell is situated at the lower end of the freshwater portion of the James Estuary. At Hopewell the Appomattox River, having a drainage area of 1,335 square miles above the U.S.G.S. gage near Petersburg, merges with the James. The fact that the James at this location is tidal but not saline enhances its development appeal to large water use type industries. A rather sudden increase in volume capacity of the Estuary at Hopewell provides a large amount of storage for freshwater, thereby, making available considerably larger yields than the river flow itself.

b. Present Water Quality

A dissolved oxygen sag, depressing the DO to less than 4 mg/l, has been observed in the Hopewell vicinity under summer temperature conditions. The organic waste load to the river at this location is higher than any other water service area in the basin, but the capacity of the river to assimilate oxygen demanding

wastes is also greater than at points upstream. The effect of this high organic load on the river is more serious than is reflected by the dissolved oxygen parameter alone. Floating solids, sludge deposits, and highly turbid discharges from severely polluted creeks such as Bailey Creek in Hopewell, all give visual evidence that inadequately treated waste is being discharged.

The U. S. Fish and Wildlife Service (see Appendix B) reports that fish populations are moderately affected by pollution from municipal and industrial waste for about 25 miles below Petersburg.

c. Major Sources of Waste and Present Pollution Abatement Practices

Approximately 85 per cent of the wastes discharged to water courses in the Hopewell-Petersburg Area are of an industrial origin. Paper and chemical production processes are the largest contributors. Taking the Area as a whole, an organic waste load of 730,000 population equivalents, 610,000 of which are from industrial sources, is presently being discharged. This load would be reduced by approximately 75 per cent if all waste contributors provided treatment equivalent to 85 per cent reduction of biologically oxidizable wastes. Table XVIII itemizes the major waste sources and their respective loads.

d. Recommended Immediate Pollution Control Needs

Considering the fact that upgrading waste treatment practices to a minimum of 85 per cent removal will result in a 75 per cent reduction in total waste load produced by the water service area, it is recommended that a policy of secondary treatment by all waste contributors be adopted and implemented. Conventional secondary treatment or other waste reduction methods capable of reducing waste loads by 85 per cent BOD removal are feasible pollution abatement measures and should preclude alternate methods of maintaining specific water quality objectives in receiving streams.

Bailey Creek is a small tributary to the James, draining only 20 square miles in the Hopewell area. This small stream is the recipient of approximately 300,000 population equivalents of organic wastes, principally from the Hercules Powder Company, although the City of Hopewell and the Fort Lee Military Reservation both discharge their domestic wastes to this watershed. The bulk of this load is introduced into the watershed within three miles from the mouth of Bailey Creek. This lower end of the creek,and a large area of the James into which it empties, is very shallow and swampy. Physically, this body of water is not suitable for assimilating or transporting large quantities of wastes. To remedy the existing condition of severe pollution in Bailey Creek, it is suggested that either a very high degree

of treatment be employed by Hercules Powder Company, or the company relocate its outfall to a more suitable receiving body of water such as the James River Channel. Detailed engineering studies, considering the problem of waste outfall locations in Bailey Creek, should be made simultaneously with plans for waste reduction to a minimum of 85 per cent BOD removal at all waste discharges.

The estimated total annual cost for implementing the above recommended action in the area is $1,100,000.

TABLE XVIII

PRINCIPAL WASTE DISCHARGES
IN THE PETERSBURG-HOPEWELL AREA

Location	Types of Waste	Type or Efficiency of Waste Removal	Waste Load Discharged P E
Hopewell	Municipal	Primary	11,000
Petersburg	Municipal	Primary	96,000
Colonial Heights	Municipal	Primary	9,000
Allied Chemical Co. (Chemical)	Industrial	None	47,000
Allied Chemical Co. (Nitrogen)	Industrial	None	59,000
Allied Chemical Co. (Fibers)	Industrial	None	8,000
Continental Chemical Co.	Industrial	50%	195,000
Hercules Powder Co.	Industrial	40%	294,000
Firestone Co.	Industrial	None	1,000
Fort Lee Military Reservation	Sanitary	Primary	6,000
Total for Water Service Area			726,000

e. Water Supply Needs

Hopewell is located at the confluence of the Appomattox and James Rivers in tidewater but above the intrusion of significant salt concentrations. The availability of large quantities of fresh water has no doubt been a significant factor in the location of several large water-using industries in this area. The total water use for other than power production is presently about 253 mgd. The fifty-year outlook is for an increase to over four times this amount by the year 2020, (see Table XIX). The present quantity of surface water is sufficient to meet this increase, but water quality deterioration must be halted and salt water intrusion controlled by returning the used water to the James.

TABLE XIX

PRESENT AND PROJECTED WATER SUPPLY REQUIREMENTS

FOR THE HOPEWELL-PETERSBURG AREA

	Average Daily Demand (mgd)		
	1965	1980	2020
Municipal	40*	24	83
Industrial	213	560	980
Total for Water Service Area	253	584	1,063

* Old Dominion Water Corporation provides water for several industries in the water service area. Projected requirements separate municipal and industrial uses.

G. Hampton Roads Area

1. James River Watershed

a. Pertinent Hydrologic Characteristics

The James River is the southernmost river draining into the Chesapeake Bay and, as such, enters the bay very near its' mouth. The Hampton Roads area, at the mouth of the James, is an important international shipping center. The average salinity at Old Point Comfort, on the northern penisula, is about 20 parts per thousand. Two small tributary watersheds, the Nansemond and the Elizabeth, drain to the Hampton Roads area from the southern peninsula. The headwaters of the Nansemond are almost completely dammed for freshwater supply sources. Few, if any, suitable sites are available for freshwater impoundments on the Elizabeth watershed.

b. Present Water Quality

During 1965 and 1966 the Virginia Institute of Marine Sciences, under contract with the Federal Water Pollution Control Administration, conducted a routine biological and chemical sampling study on the tidal James River. The following excerpts from a report of this study sum up the current water quality in this section of the James Estuary.

The estuarine portion of the James River is a major oyster producing area in the Chesapeake Bay. In 1966, over 500,000 bushels of shucking oysters were harvested for marketing and over

600,000 bushels of seed oysters were harvested for replanting in other rivers. This harvest represents only a fraction of past and potential levels because breeding populations in the lower Estuary have been destroyed by the protozoan Minchinia nelsoni, which is often referred to as MSX.

In the estuarine portion hundreds of acres of oyster beds are condemned for direct harvesting. This industry cannot exist in close proximity to concentration of human activities, and even if all outfalls were removed most areas would remain condemned. The other intended uses of Hampton Roads are not curtailed.

The estuarine portion of the James, i.e. from Jamestown Island to the mouth, is a suitable environment for aquatic life, and the water quality meets the standards required for all uses except direct marketing of shellfish harvested from populated areas. Protection of this area is dependent upon careful evaluations of all proposed waste discharges into the Estuary and maintenance of active programs to improve and control the water quality of the tributary streams. These controls are actively enforced by the State Water Control Board and its cooperating state agencies.

In addition to these observations, the Virginia State Water Control Board has conducted extensive studies on the Nansemond River. A report of these studies is included in the Water Control Board's Record of Hearings on the Nansemond River held on March 23, 1965. This report contains data which show

dissolved oxygen concentrations of less than 1 mg/l in the upper Nansemond where the City of Suffolk as well as several industries discharge biologically degradable wastes.

c. Major Sources of Waste and Present Pollution Abatement Practices

Municipal wastes constitute the major portion of the total biologically degradable waste loads discharged to the Hampton Roads area and its tributaries. Existing municipal waste treatment plants in the area treat approximately 650,000 population equivalents of waste, while available industrial waste data indicate an industrial production of about 125,000 population equivalents. Of the total 775,000 PE's produced, about 300,000 are removed by treatment.

Most of the waste treatment facilities in the area provide only primary treatment with strictly enforced, high chlorination standards to protect the shellfish industry. Substantial improvements by effluent chlorination have been made insofar as shellfish harvesting is concerned in the James River and Hampton Roads waters. Tributary waters, however, have become increasingly worse as a result of the rapidly growing population of the area. Table XX lists the major waste sources, their present treatment and loads.

TABLE XX

PRINCIPAL WASTE DISCHARGES
IN THE HAMPTON ROADS AREA

Location	Type of Waste	Type or Efficiency of Waste Removal	Waste Load Discharged P E
Army Base Plant	Municipal	Primary	56,000
Lembert Point Plant	Municipal	Primary	160,000
Portsmouth	Municipal	Primary	84,000
Suffolk	Municipal	Secondary	6,000
Boat Harbor Plant	Municipal	Primary	120,000
Patrick Henry Plant	Municipal	Primary	3,000
Best Foods	Industrial	20%	5,300
Gwaltney	Industrial	Lagoon (75%)	12,000
Joel Harrell & Sons	Industrial	Lagoon (75%)	8,500
Luters	Industrial	Lagoon (75%)	4,700
Virginia Packing	Industrial	Lagoon (75%)	4,700
Total for Water Service Area			465,000

d. Recommended Immediate Pollution Control Needs

This important area, the most heavily populated metropolitan center in the entire James River Basin, should and could be doing more to protect its valuable water resources. Even though the present primary treatment waste effluents discharging directly to the main body of the James River may not appreciably

affect the dissolved oxygen content of the river, secondary treatment is an economically feasible pollution abatement measure that would have long term benefits as well as present aesthetic benefits. The major sewage treatment facilities in the area could be improved by secondary treatment at an estimated total annual cost of $750,000.

The Hampton Roads Sanitation District, the sewerage and sewage disposal management organization for the cities of Newport News, Hampton, and Norfolk, initiated engineering studies for an expansion and development program of the area's sewage disposal facilities. A report of these studies was published in 1960 and calls for an initial construction of four new treatment plants totaling 12 mgd in capacity as well as expansion of waste collection facilities. A total cost of $11,000,000 was estimated for this initial development in the near future. On the basis of 4½ per cent interest and depreciation over 20 years, the total annual cost would be about $850,000, including operation and maintenance. It is recommended that the district expedite this development plan as well as the previously recommended secondary treatment program for all waste discharges.

The approximate total annual cost of the recommended program is $1,800,000.

e. Water Supply

In the heavily populated Hampton Roads area, sources of freshwater for municipal water supply are limited. Existing

supplies for the cities of Newport News, Hampton, Williamsburg, Norfolk, Portsmouth, Suffolk, and Virginia Beach deliver an average of 90 million gallons a day for municipal water use. The combined safe yield of all facilities serving these cities is about 118 mgd. Table XXI shows the projected municipal water supply requirements of the water service area for 1980 and 2020. From the Table it can be seen that the water needs will exceed the present safe yield before 1980.

The Appomattox River above Petersburg has been considered as a potential site for the development of a water supply reservoir to serve the entire lower James River Basin, including Petersburg, Colonial Heights, Hopewell, Chesterfield County, Norfolk, Portsmouth, and Newport News. A consulting engineers' report on this development indicates that the potential to meet the municipal water supply requirements through the year 2020 is available on the Appomattox.

TABLE XXI

PRESENT AND PROJECTED WATER SUPPLY REQUIREMENTS FOR THE HAMPTON ROADS AREA

	Average Daily Demand (mgd)		
	1965	1980	2020
Municipal	90.0	132	280

APPENDIX A

Biological Survey of the Jackson and James Rivers

BIOLOGICAL SURVEY OF THE JACKSON RIVER

(Between Clearwater Park, Virginia,
and the Cowpasture River, Virginia)

I. INTRODUCTION

A biological survey of the Jackson River between Clearwater Park, Virginia, and the Cowpasture River, Virginia, was conducted from July 13 through July 14, 1966.

For purposes of the study, the community of bottom (benthic) organisms was selected as the indicator of the biological condition of the stream. Bottom organisms serve as the preferred food source for the higher aquatic forms and exhibit similar reactions to adverse stream conditions. The combination of limited locomotion and life cycles of one year or more, for most benthic species, provide a long-term picture of the water quality of a stream. Fish and algal populations were given some consideration, but only to the extent that obvious conclusions could be drawn based upon casual observations.

In unpolluted streams, a wide variety of sensitive clean-water associated bottom organisms are normally found. Typical groups are stoneflies, mayflies, and caddisflies. These sensitive organisms usually are not individually abundant because of natural predation and competition for food and space; however, the total count or number of organisms at a given station may be high because of the number of different varieties present.

Sensitive genera tend to be eliminated by adverse environmental conditions (e.g., chemical and/or physical) resulting from wastes reaching the stream. In waters enriched with organic wastes, comparatively fewer kinds (genera) are normally found, but great numbers of these genera may be present. Organic pollution-tolerant forms such as sludgeworms, rattailed maggots, certain species of bloodworms (red midges), certain leeches, and some species of air-breathing snails may multiply and become abundant because of a favorable habitat and food supply. These organic pollution-tolerant bottom organisms may also exist in the natural environment but are generally found in small numbers. The abundance of these forms in streams heavily polluted with organics is due to their physiological and morphological abilities to survive environmental conditions more adverse than conditions that may be tolerated by other organisms. Under conditions where inert silts or organic sludges blanket the stream bottom, the natural home of bottom organisms is destroyed, causing a reduction in the number of kinds of organisms present.

In addition to sensitive and pollution-tolerant forms, some bottom organisms may be termed intermediates, in that they are capable or living in fairly heavily polluted areas as well as in clean-water situations. These organisms occurring in limited numbers, therefore, cannot serve as effective indicators of water quality.

Streams grossly polluted with toxic wastes such as mine drainage will support little if any biological life and will reduce the population of both sensitive and pollution-tolerant organisms.

Classification of organisms in this report is considered in three categories (clean-water associated, intermediate, and pollution-tolerant) which provides sufficient biological information to supplement physical and chemical water quality data for this study area. Tentative identification and counts of specific organisms have been tabulated for use during intensive investigations of selected areas and are available upon request.

II. SUMMARY AND CONCLUSIONS

1. A biological survey of the Jackson River between Clearwater Park and Iron Gate, Virginia, plus the lower end of the Cowpasture River in Virginia was made July 13 to 14, 1966. Investigations were made at eight stations on the Jackson River and at one station on the Cowpasture River.

2. Bottom organisms were selected as the primary indicator of biological water quality.

3. From Clearwater Park, Virginia, to the Covington, Virginia, Water Filtration Plant, extremely high water quality was found.

4. From the Covington, Virginia, Playground Park to Iron Gate, Virginia, degraded biological conditions were found.

5. The Cowpasture River was found to contribute high quality water to the Jackson to form the James River.

6. Based on known biological sampling, the River has recovered by the time it reaches Salisbury, Virginia, which is a short distance downstream from Eagle Rock, Virginia.

III. DATA EVALUATION AND INTERPRETATION

The Jackson River joins the Cowpasture River downstream from Iron Gate, Virginia, to form the James River. The Jackson River was sampled between Clearwater Park (upstream from Covington, Virginia) and Iron Gate, Virginia, in order to evaluate the biological conditions of this stretch of stream.

Sampling stations were located after consideration of the following conditions:

1. Tributaries
2. Areas having a known waste problem
3. Physical capability for sampling

Bottom organisms are animals that live directly in association with the bottom of a waterway. They may crawl on, burrow in, or attach themselves to the bottom. Macroorganisms are usually defined as those organisms that will be retained by a No. 30 sieve. In essence, the organisms retained by the sieve are those that are visible to the unaided eye.

Each station was sampled once, and the kinds of macro bottom organisms were observed for the purpose of evaluating water quality. Quantitative bottom samples were also taken, using a Surber Square Foot Sampler or a Petersen Dredge (0.6 square feet), and the number of organisms per square foot were counted or calculated.

Quantitative samples were not taken at some stations because of poor physical sampling conditions or organisms were sparse.

Station #1 - Jackson River at the riffle immediately upstream from the Virginia Route 687 Bridge at Clearwater, Virginia

The water at this station was extremely clear, and numerous smallmouth bass were observed throughout the area. High water quality was indicated by the 48 kinds (genera) of bottom organisms. They included such clean-water forms as stoneflies (three genera), mayflies (four genera), caddisflies (11 genera), fishflies, hellgrammites, riffle beetles (two genera), and gill-breathing snails (three genera). A total of 288 bottom organisms were collected in the square foot sample which included 86 mayflies, 24 caddisflies, three stoneflies, 83 gill-breathing snails, ten riffle beetles, and one fishfly. The clean-water organisms made up 78 per cent of the quantitative sample. Based on the bottom organisms, excellent water quality was indicated at this station.

Station #2 - Jackson River at the riffle approximately 100 yards upstream from the Covington, Virginia, Water Filtration Plant

Numerous smallmouth bass and darters were observed in the clear water at this station. A small group of children were seen swimming downstream from the water filtration plant. High water quality was again indicated by the 38 kinds (genera) of bottom organisms which included such clean-water forms as mayflies (eight genera), caddisflies (eight genera), stoneflies (one genera), riffle beetles (two genera), and hellgrammites.

A total of 426 bottom organisms were collected in the square foot sample which included 95 mayflies, 51 caddisflies, and 94 riffle beetle larvae. Clean-water organisms made up 56 per cent of the total in the quantitative sample. High diversification and numerous clean-water forms indicated excellent water quality.

Station #3 - Jackson River at the Covington, Virginia, Playground Park

This station was located approximately 0.7 of a mile downstream from the pulp and paper company and adjacent to the Covington Municipal Playground. Virtually all of the rocks were coated with a heavy, black slime believed to be Sphaerotilus sp. The water was a dark, coffee color at this station.

The water temperature was elevated, and foam was observed. In addition, a strong odor characteristic of a mill operation was noted. The air-breathing snail Physa was present in fair numbers, but these snails were all at the waterline and on the rocks. For this reason, a quantitative sample was not taken. Only a few sludgeworms and another bristleworm (Nais sp.) were found in addition to the Physa snails. Severe biological degradation is indicated at this station when compared with the upstream station. The enormous drop in genera from 38 (upstream station) to three at this station, plus the complete absence of clean-water forms, indicated heavy industrial pollution. All three kinds of bottom organisms found at this station were pollution-tolerant forms.

The low dissolved oxygen and high water temperatures found by VMI sampling during this period further substantiate the poor biological conditions.

Station #4 - Jackson River at the riffle immediately downstream from the Durant Road Bridge due south of Covington, Virginia

Here the water conditions of the previous station: a coffee color, foaming, and an elevated temperature persisted. Again black slime coated the rocks, and the strong odor prevailed. The only bottom organisms present in fair numbers were the air-breathing Physa snails which were exposed at the waterline and on the rocks. The only other bottom organism found was the bristleworm Nais sp. Degraded biological conditions were still indicated by the presence of these two pollution-tolerant forms and the absence of clean-water bottom organisms.

Station #5 - Jackson River at the Drive-In Theatre east of Covington on Routes 60 and 220

The water still remained coffee colored and foaming. Rocks were covered with a glay slime-like growth believed to be Sphaerotilus sp. The only bottom organisms found were pollution-tolerant sludgeworms, the air-breathing snail Physa, and an intermediate midge larva. The quantitative sample consisted of 488 sludgeworms. Heavy biological degradation was still indicated.

Station #6 - Jackson River off U. S. 60 and 220 approximately 0.5 mile from the Low-Moor, Virginia, intersection

The coffee color and foaming prevailed at this station also. Most of the rocks were still black and covered with a grayish-black slime believed to be Sphaerotilus sp. There were good populations of the air-breathing snail Physa in certain sections of the stream, but their distribution was erratic. A quantitative sample was not taken because of the spotty distribution of bottom organisms. Such pollution-tolerant forms as leeches, horsefly larvae, another air breathing snail, and a beetle larva were also collected. Degraded biological conditions were still indicated. This indication was supported by the low dissolved oxygen readings found in the VMI survey.

Station #7 - Jackson River at the mouth of Smith's Creek in Clifton Forge, Virginia

The water continued to appear coffee colored, and foaming was present. Smith's Creek was very cloudy and appeared to be contributing a pollutional load from Clifton Forge. The rocks in the area were still black and coated with slime. Approximately 50 dead fish were observed in the area and appeared to be mostly suckers and minnows. Bottom organisms could not be found. Degraded biological conditions still existed at this point.

Station #8 - Jackson River at the last bridge crossing downstream from Iron Gate, Virginia

The water was tea colored and still showed signs of foam. Approximately ten dead fish, primarily suckers and minnows, were noted in the area. The rocks were still black, and slime was still present. The bottom organisms consisted of ten kinds, composed of pollution-tolerant and intermediate forms. The square foot sample contained 464 bottom organisms which consisted of 176 sludge-worms, 208 air-breathing snails (two genera), eight leeches, and 72 intermediate midge larvae (three genera). Degraded biological conditions were still indicated at this station, although there was some improvement. The VMI survey also indicated some improvement. While the dissolved oxygen was still appreciably low, there was a higher average reading than stations downstream from Covington, Virginia.

Station #9 - The Cowpasture River at the Virginia Route 633 Bridge

This stream was extremely clear, and numerous smallmouth bass were observed throughout the area. The surrounding area is farming country and appeared to be primarily pasture land. Twenty-two kinds of bottom organisms were found which included such clean-water forms as stoneflies (two genera), mayflies (three genera), caddisflies (three genera), and riffle beetles (two genera). There was a total of 440 bottom organisms in the square foot sample, including 26 stoneflies, 32 mayflies, 230 caddisflies, and 80

riffle beetles. Based on the great diversification of bottom organisms and the high percentage of clean-water forms, the Cowpasture River contributes high quality water to the Jackson River to form the James River downstream from this station.

BOTTOM ORGANISM DATA OF JACKSON RIVER BETWEEN
CLEARWATER PARK, VIRGINIA, AND THE COWPASTURE RIVER

Station Number	Location	Number of Organisms in Square Foot Sample			Total No. of Kinds
		Clean-Water	Inter-mediate	Pollution-Tolerant	
1	Jackson River Upstream from Route 687 Bridge, Clearwater, Virginia	207	76	5	48
2	Upstream from Covington, Virginia Water Filtration Plant	240	36	150	38
3	at Covington, Virginia, Playground Park	Quantitative Sample Not Taken			3
4	Downstream from Durant Road Bridge, Covington, Virginia	Quantitative Sample Not Taken			2
5	at Drive-In Theatre, Covington, Virginia	0	0	488	3
6	Upstream from Low-Moor, Virginia Intersection	Quantitative Sample Not Taken			5
7	at Mouth of Smith's Creek, Clifton Forge, Virginia	Quantitative Sample Not Taken			0
8	Downstream from Iron Gate, Virginia	0	72	392	10
9	Cowpasture River at Virginia Route 633 Bridge	400	22	18	22

BIOLOGICAL SURVEY OF THE JAMES RIVER

(Between the Maury River, Virginia, and
Bent Creek, Virginia)

I. INTRODUCTION

A biological survey of the James River between the first dam downstream from the Maury River and Bent Creek, Virginia, was conducted September 7 to 8, 1966. The survey was made to determine the biological condition of this reach of stream.

For purposes of the study, the community of bottom (benthic) organisms was selected as the indicator of the biological conditions of the stream. Bottom organisms serve as the preferred food source for the higher aquatic forms and exhibit similar reactions to adverse stream conditions. The combination of limited locomotion and life cycles of one year or more, for most benthic species, provide a long-term picture of the water quality of a stream. Fish and algal populations were given some consideration, but only to the extent that obvious conclusions could be drawn based upon casual observations.

In unpolluted streams, a wide variety of sensitive clean-water associated bottom organisms are normally found. Typical groups are stoneflies, mayflies, and caddisflies. These sensitive organisms usually are not individually abundant because of natural predation and competition for food and space; however, the total count or number of organisms at a given station may be high because of the number of different varieties present.

Sensitive genera tend to be eliminated by adverse environmental conditions (e.g., chemical and/or physical) resulting from wastes reaching the stream. In waters enriched with organic wastes, comparatively fewer kinds (genera) are normally found, but great numbers of these genera may be present. Organic pollution-tolerant forms such as sludgeworms, rattailed maggots, certain species of bloodworms (red midges), certain leeches, and some species of air-breathing snails may multiply and become abundant because of a favorable habitat and food supply. These organic pollution-tolerant bottom organisms may also exist in the natural environment but are generally found in small numbers. The abundance of these forms in streams heavily polluted with organics is due to their physiological and morphological abilities to survive environmental conditions more adverse than conditions that may be tolerated by other organisms. Under conditions where inert silts or organic sludges blanket the stream bottom, the natural home of bottom organisms is destroyed, causing a reduction in the number of kinds of organisms present.

In addition to sensitive and pollution-tolerant forms, some bottom organisms may be termed intermediates, in that they are capable of living in fairly heavily polluted areas as well as clean-water situations. These organisms occurring in limited numbers, therefore, cannot serve as effective indicators of water quality.

Streams grossly polluted with toxic wastes such as mine drainage will support little, if any, biological life and will

reduce the population of both sensitive and pollution-tolerant organisms.

Classification of organisms in this report is considered in three categories (clean-water associated, intermediate, and pollution-tolerant) which provide sufficient biological information to supplement physical and chemical water quality data for this study area. Tentative identification and counts of specific organisms have been tabulated for use during intensive investigations of selected areas and are available upon request.

II. SUMMARY AND CONCLUSIONS

1. Unpolluted biological conditions were indicated between the first dam downstream from the Maury River and Battery Creek.

2. Mild degradation was indicated between Skimmer Creek and upstream from the low level dam at Coleman Falls, Virginia.

3. Recovery conditions were indicated from downstream from the low level dam at Coleman Falls, Virginia, to Holcomb Rock upstream from Lynchburg, Virginia.

4. Mild degradation was indicated at Daniel Island opposite Lynchburg, Virginia.

5. Moderate to heavy pollution was indicated at Six Mile, Virginia.

6. Mild pollution was indicated between Galts Mill and Stapleton, Virginia.

7. Fair water quality was indicated at Christian Mill Creek, Virginia.

8. Good water quality was indicated from Riverdale, Virginia, to Allen Creek which is upstream from Bent Creek, Virginia.

III. DATA EVALUATION AND INTERPRETATION

The James River is a fairly substantial stream between the Maury River and Bent Creek, Virginia. In this reach are located two paper operations and the industrial community of Lynchburg, Virginia.

Sampling stations were located after consideration of the following conditions:

1. Tributaries
2. Areas having a known waste problem
3. Physical capability for sampling

Bottom organisms are animals that live directly in association with the bottom of a waterway. They may crawl on, burrow in, or attach themselves to the bottom. Macroorganisms are usually defined as those organisms that will be retained by a No. 30 sieve. In essence, the organisms retained by the sieve are those that are visible to the unaided eye.

Each station was sampled once, and the kinds of macrobottom organisms were observed for the purpose of evaluating water quality. Quantitative bottom samples were also taken using a Surber Square Foot Sampler or a Petersen Dredge (0.6 square feet), and the number of organisms per square foot were counted or calculated.

Quantitative samples were not taken at some stations because of poor physical sampling conditions or organisms were very sparse.

Station #1 - James River approximately 100 yards downstream from the first dam downstream from the Maury River near Glasgow, Virginia

The water at this station was very clear, and numerous fish were observed throughout the area. Most of these fish were minnows. Good water quality was indicated by the 16 kinds (genera) of bottom organisms collected which included such clean-water forms as caddisflies (four genera), gill-breathing snails (three genera), and riffle beetles. Out of a total of 2,025 bottom organisms in the square foot sample, there were 536 caddisflies and 64 riffle beetles, or 30 per cent of the quantitative sample. Good water quality was indicated at this location.

Station #2 - James River approximately 50 yards upstream from Battery Creek (West Bank) which is upstream from Big Island, Virginia

Numerous minnows were observed at this station. The water appeared to be a light, tea color but was clear in the bottle. Sampling had to be confined to about four to five feet off the bank because of the sharp drop-off, and a quantitative sample was not taken for this reason. Nine kinds of bottom organisms were found which included gill-breathing snails (one genera), air-breathing snails (two genera), flatworms, leeches, and intermediate midge larvae (four genera). Fair to good water quality was indicated; however, it is strongly believed a much greater diversification could have been found if a riffle area had been present. Based on known dissolved oxygen readings,

other water chemistry, and this limited biological sampling, unpolluted biological conditions were indicated at this station.

Station #3 - James River immediately upstream from Skimmer Creek and downstream from Big Island, Virginia

The water was a dark, tea color, and fish could not be found. Due to a very sharp drop-off, bottom sampling had to be confined to the immediate bank. Bottom organisms could not be found in this area. While there appears to be some slight degradation, it is difficult to make a judgment based on bottom organisms because of poor sampling conditions and the lack of a riffle area. Based on dissolved oxygen readings and other known water chemistry, this station does not appear to have a really serious problem, although some degradation was present. Water quality could only be described as mildly degraded at this location.

Station #4 - James River upstream from the low level dam at Coleman Falls, Virginia

The water continued to be tea colored but was clear in the bottle. The bottom in this area appeared to be coated with a black, gelatinous material, and bottom organisms were sparse. Only a few bloodworms and a bristleworm (Nais sp.) could be found. Again sampling had to be confined to the bank area due to the sharp drop-off. Because of the drop-off and the sparse bottom organism population, a quantitative sample was not taken. A few minnows were observed in the sample area. Based on the bottom

organisms and known dissolved oxygen readings, mild degradation was still indicated at this station.

Station #5 - James River approximately 150 yards downstream from the low level dam at Coleman Falls, Virginia

The water still appeared tea colored but again was clear in the bottle. Only six kinds of bottom organisms were present, and they were sparse. They consisted of a gill-breathing snail, an air-breathing snail, flatworms, a bristleworm, a dragonfly nymph, and a few intermediate midge larvae. Sampling still had to be confined to the banks because of the sharp drop-off. A quantitative sample was not taken because of the poor sampling conditions and sparse population. Based on the known water chemistry at this station, recovery appeared to have occurred despite the low number of bottom organisms. It is believed the low number of bottom organisms sampled can be attributed to the poor sampling conditions created by the impoundments in this area.

Station #6 - James River at Holcomb Rock upstream from Lynchburg, Virginia

The water continued tea colored but again was clear in the bottle. Bottom organisms were sparse, and only a few sludge-worms and gill-breathing snails could be found. Due to a sharp drop-off and impoundment conditions, sampling had to be confined to the banks. The water chemistry at this station indicated that recovery had occurred at this station. The poor bottom organism

population is attributed to poor sampling conditions and poor habitat created by impounded conditions.

Station #7 - James River downstream from a low level dam downstream from Daniel Island opposite Lynchburg, Virginia (East Bank)

The water was dark, tea color but was clear in the bottle. Foam had built up in sections below the dam similar to detergent suds. A fisherman was observed in the area, and a dead channel catfish approximately eight inches long was found. Only a qualitative sample was taken due to the drop-off and large rocks. Eight kinds of bottom organisms were sampled which included gill-breathing snails (two kinds), air-breathing snails (two kinds), Fingernail clams, flatworms, the scud Gammarus sp., and an intermediate midge larvae. Mild degradation appeared to be present at this station.

Station #8 - James River at Six Mile, downstream from Lynchburg, Virginia

The water at this location was very turbid, and clumps of dead algae were observed floating. Sludge deposits were heavy along the shore and prevented wading out very far from the bank. The only bottom organisms found were sludgeworms and mosquito larvae, both of which are pollution-tolerant. Sludgeworms were abundant. Moderate to heavy degradation was indicated at this location based on the bottom organisms and known dissolved oxygen readings.

Station #9 - James River at Galts Mills

The water at this location was tea colored but was clear in the bottle. A total of 15 genera of bottom organisms were found at this station, including mayflies (one kind) and gill-breathing snails (one kind). Other kinds sampled included such intermediate forms as fingernail clams, the scud Gammarus sp., damselflies (two kinds, and dragonflies (one kind). Pollution-tolerant organisms included sludgeworms, mosquitoes, air-breathing snails (two kinds), and leeches (two kinds). A quantitative sample was not taken because the bottom was predominately bedrock. The river appeared to be recovering at this station, but recovery had not yet occurred. Mild pollution was still indicated.

Station #10 - James River at Stapleton, Virginia

The tea color was still present, but the water was clear in the bottle. There was a recent moderate to heavy fish kill of white suckers in the area, the majority of the suckers averaging one pound in weight. A large school of white suckers had sought refuge in Partridge Creek and refused to leave the creek and venture out into the James River, despite being disturbed by the sampling activities in the mouth of the creek. A total of ten kinds of organisms were sampled at this station, consisting of gill-breathing snails (two kinds), air-breathing snails (two kinds), fingernail clams, leeches (two kinds), flatworms, and intermediate midge larvae (two kinds). A quantitative sample

was not taken because the riffle area was made up of large bedrock. Mild pollution was still indicated.

Station #11 - James River immediately upstream from Christian Mill Creek

The water at this location still had a tea color but was clear in the bottle, indicating the color was caused by the substrate. Aquatic vegetation was heavy and included duckweed, filamentous algae, moss, and submerged aquatic vegetation. Twelve kinds of bottom organisms were found (versus ten upstream), including such clean-water forms as caddisfly larvae (two kinds) and gill-breathing snails (two kinds). Also included were air-breathing snails (one kind), fingernail clams, flatworms, sludgeworms, damselflies, another bristleworm, and intermediate midge larvae (two kinds). Out of 1,128 bottom organisms in the square foot sample, there were 776 flatworms, 184 caddisflies, 128 intermediate midge larvae, 24 sludgeworms, eight bristleworms, and eight gill-breathing snails. Fair water quality was indicated at this station.

Station #12 - James River at Riverdale, Virginia

The water still appeared tea colored but was clear in the bottle. The bottom organism at this station took a great upsurge in diversification. Twenty-three kinds were found (versus 12 at the upstream station), including such clean-water bottom organisms as caddisflies (four kinds), mayflies, riffle

beetles (two kinds), and gill-breathing snails (two kinds). Out of 706 bottom organisms in the square foot sample, there were 280 caddisflies, 232 flatworms, 152 intermediate larvae, 24 riffle beetles, nine air-breathing snails, and one unidentified bristleworm. The river appeared to have recovered at this point, and good water quality was indicated.

Station #13 - James River at Allen Creek upstream from Bent Creek, Virginia

The water was still tea colored but clear in the bottle. The surrounding land is in farmland, and siltation appeared heavy. The drop-off was sharp beyond the silted area, and sampling conditions for bottom organisms was extremely poor. Only three kinds of bottom organisms were found. A quantitative sample was not taken because sampling had to be confined close to the banks due to the soft banks and drop-off. The only clean-water form found was a gill-breathing snail. In addition, an air-breathing snail and damselflies (one kind) were found. The poor bottom organism population was attributed to the heavy siltation, absence of a riffle area, and generally poor sampling habitat. Based on the known dissolved oxygen readings and other water chemistry at this station, good water quality still existed at this location.

BOTTOM ORGANISM DATA OF JAMES RIVER BETWEEN THE MAURY RIVER, VIRGINIA, AND BENT CREEK, VIRGINIA

Station Number	Location	Number of Organisms In Square Foot Sample			Total No. of Kinds
		Clean-Water	Inter-mediate	Pollution-Tolerant	
1	James River Downstream from confluence of Maury River, Glasgow, Virginia	600	1,240	185	16
2	Upstream from Battery Creek (W.B.), Big Island, Virginia	Quantitative Sample Not Taken			9
3	Upstream from Skimmer Creek, Big Island, Virginia	Quantitative Sample Not Taken			0
4	Upstream from low level dam, Coleman Falls, Virginia	Quantitative Sample Not Taken			2
5	Downstream from low level dam, Coleman Falls, Virginia	Quantitative Sample Not Taken			6
6	at Holcomb Rock, Lynchburg, Virginia	Quantitative Sample Not Taken			2
7	Downstream from low level dam, opposite Lynchburg, Virginia (E.B.)	Quantitative Sample Not Taken			8
8	at Six Mile, downstream from Lynchburg, Virginia	Quantitative Sample Not Taken			2
9	at Galts Mills, Virginia	Quantitative Sample Not Taken			15
10	at Stapleton, Virginia	Quantitative Sample Not Taken			10
11	Upstream from Christian Mill Creek	192	904	32	12
12	at Riverdale, Virginia	304	384	18	23
13	at Allen Creek upstream from Bent Creek, Virginia	Quantitative Sample Not Taken			3

APPENDIX B

A Report on the Effects of Pollution
on Stream Fishery Resources
in the James River Basin

By

U. S. Department of the Interior
Fish and Wildlife Service
April 1967

EFFECTS OF POLLUTION OF FISH POPULATION IN THE JAMES RIVER BASIN

The geographic area covered by these interim data contains 2,556 miles of streams, comprising 87,826 surface acres, which provide significant value fish habitat. These waters in an unpolluted condition are capable of annually supporting 4,117,500 man-days of quality fishing. This total capability is based on an average daily creel of one pound per fishing trip and a yearly sustained average yield that would not detrimentally affect quality of the fishery. Currently, pollution is estimated to cause an annual reduction of 796,850 man-days of fishing potential. This figure represents 19.4 per cent of the total fresh water stream fishing opportunity available in the James River Basin.

Table A provides detailed data of basin fresh water fishery habitat, its use and productivity, and the affect of pollution on the resources. A narrative description of each polluted section follows the Table.

TABLE A

SUMMARY STREAM CLASSIFICATION FOR
JAMES RIVER BASIN, VIRGINIA, APRIL 1967

Ecological Class	Stream Miles	Acreage	Current Fishing Pressure (Total M-D)	Annual Sustainable Fishing Pressure (M-D/Ac)	Maximum Annual Use Without Pollution (M-D)	Maximum Annual Use With Pollution (M-D)	Total Reduction Fishing Potential (M-D)
11	226	64,340	182,245	50/Ac	3,217,000	2,465,500	751,500
9	80	1,013	13,170	50/Ac	50,700	50,700	None
7	139	1,908	86,527	40/Ac	76,300	76,090	210
6	782	18,293	142,511	40/Ac	731,700	686,900	44,800
5	138	276	7,150	25/Ac	6,900	6,900	None
4	735	1,154	24,502	12/Ac	13,800	13,460	340
3	236	635	84,606	25/Ac	15,900	15,900	None
2	220	207	51,266	25/Ac	5,200	5,200	None
Sub-Total Tidal	226	64,340	182,245		3,217,000	2,465,500	751,500
Sub-Total Non-Tidal	2,330	23,486	409,732		900,500	855,150	45,350
TOTALS	2,556	87,826	591,977		4,117,500	3,320,650	796,850

JAMES RIVER - Mile 23.0 - 38.5

1. Location: The entire section of the James River between Jamestown, Virginia, and the Surry-Isle of Wight County Line.
2. Data Reference: 1, 6.
3. Pollution Sources: (a) Hopewell residential and industrial wastes, (b) Richmond residential and industrial wastes.
4. Pollution Effects: Fishery resources are lightly affected by pollution. Although the river immediately above this segment is in a seeming state of oxygen depletion recovery, large fish kills occur in this river section yearly. These kills were recorded[6] in 1964 and 1965. Circumstances behind these fish kills are not completely understood. A complex series of events involving some delayed chemical reaction coupled with tidal effect is thought responsible. During most of the year the fishery appears unaffected.

JAMES RIVER - Mile 38.5 - 53.3

1. Location: The entire section of the James River from a few miles below Weyanoke to Jamestown, Virginia.
2. Data Reference: 1.
3. Pollution Sources: (a) Hopewell industrial and residential wastes, (b) Richmond residential and industrial wastes.
4. Pollution Effects: Fishery resources are insignificantly affected by pollution. The river in this segment is in a state of recovery. Altnough pollutants are present, their effect on fishery resources is considered minor.

JAMES RIVER - Mile 53.3 - 77.0

1. Location: The entire section of the James River from Hopewell, Virginia, to a few miles below Weyanoke, Virginia.
2. Data Reference: 1, 6.
3. Pollution Sources: (a) Richmond industrial and residential wastes; (b) Petersburg industrial and residential wastes; (c) Hopewell industrial and residential wastes; (c) Significant industrial waste sources from Hopewell include Firestone Synthetic Fabric, Hercules Powder Company, and Continental Can Company.
4. Pollution Effects: Fishery resources are moderately affected by pollution. A large waste load from Hopewell reduces water quality in this river segment. Very little data is available on water quality characteristics in this area. However, it is believed that low oxygen levels combine with various other toxicants, lowering water quality for fish. A large fish kill was recorded[6] covering over 14 miles of this segment in 1961.

Resident species are composed mostly of rough fish able to endure low water quality conditions. Spring anadromous spawning runs are not usually adversely affected and are subject to heavy fishing pressures.

JAMES RIVER - Mile 77.0 - 97.2

1. Location: The entire section of the James River from the confluence of Falling Creek to Hopewell, Virginia
2. Data Reference: 1, 5.
3. Pollution Sources: (a) industrial and residential wastes from Richmond, Virginia
4. Pollution Effects: Fishery resources are moderately affected by pollution. Organic waste loads from Richmond result in low dissolved oxygen levels in this river segment during warm weather periods. However, water quality tests[5] performed in 1962-1964 indicated the river was in a state of recovery in this stream segment. Additionally, detrimental effects of other deleterious substances are believed somewhat reduced. Pollution mainly affects resident species composed primarily of low populations of rough fish which can exist in less desirable environmental conditions. A large spring anadromous spawning run is exposed to a short period of heavy angling pressure.

JAMES RIVER - Mile 97.2 - 105.2

1. Location: The entire segment of the James River from Bosher Dam in Richmond to the downstream confluence of Falling Creek.
2. Data Reference: 1, 5, 6, 7.
3. Pollution Sources: (a) Richmond industrial and residential waste loads; (b) Significant industrial contributors include Federal Bond and Paper Company, Richmond Guano Company, Depont Chemical Corporation, Standard Paper Company, Virginia Carolina Chemical Company, and National Analine Division.
4. Pollution Effects: Fishery resources are severely affected by pollution. High organic waste loads reduce dissolved oxygen concentrations in this river segment during warm weather periods. State water quality tests[5] made during 1962-1964 substantiate dissolved oxygen concentrations below 3 mg/l. In addition, it is thought that heavy metals, acids, phenols, and other deleterious substances combine to significantly reduce the capacity of the water for providing good quality fish habitat. Fish kills are known to occur in this area yearly. A large kill was recorded in 1964[6], and one of unknown extent was recorded in 1961. High spring flows usually dilute pollution sufficiently to permit anadromous runs to penetrate

as far as Bosher Dam. Occasionally the spawning run suffers losses due to polluted conditions. Most of the fishing pressure in this river segment is attributable to angling pressure during the spawning runs.

JAMES RIVER - Mile 208.0 - 214.0

1. Location: The entire section of the James River from the confluence of the Buffalo River near Nordwood, Virginia, to the vicinity of Wingina, Virginia.
2. Data Reference: 1, 6.
3. Pollution Sources: (a) Lynchburg residential and industrial wastes, (b) pollution load from the Buffalo River.
4. Pollution Effects: Fishery resources are lightly affected by pollution. No recorded water quality data is available for this segment of the James River. Water conditions present some problems occasionally. In 1963 a large fish kill was reported[6] near Wingina. The major fishery problem attributable to pollution in this area is a reported bad flavor of fish flesh. Sport fishing pressure is reduced because of this phenomenon, according to local game wardens.

JAMES RIVER - Mile 230.0 - 254.0

1. Location: The entire section of the James River from Lynchburg to Riverville, Virginia
2. Data Reference: 1, 4, 5, 6.
3. Pollution Sources: (a) Lynchburg residential and industrial wastes, (b) waste load of upper James River.
4. Pollution Effects: Fishery resources are lightly affected. Organic wastes from Lynchburg coupled with waste loads present in the river reduce dissolved oxygen concentrations throughout the entire river segment during warm weather periods. Dissolved oxygen concentrations are particularly low immediately below Lynchburg. Both VMI[4] and State data[5] substantiate this fact. Occasionally water quality may drop so low that it cannot support fish life. In 1962 a large fish kill was reported[6] which covered over four miles of the river below Lynchburg. Generally water quality is adequate and supports populations of rough fish along with some game fish. Recruitment of fish from tributaries and other stream areas increases the quality of the local fishery. Wardens and biologists report disflavored fish flesh occurs during certain periods of the year which in turn reduces fishing demand.

JAMES RIVER - Mile 301.7 - 339.7

1. Location: The entire section of the James River from the confluence of the Jackson and Cowpasture Rivers to the vicinity of Buchanan, Virginia
2. Data Reference: 1.
3. Pollution Sources: (a) Covington residential and industrial wastes; (b) Clifton Forge residential and industrial wastes; (c) organic wastes from Covington and an unknown chemical substance from Clifton Forge are thought to be the main pollutants.
4. Pollution Effects: Fishery resources are moderately affected by pollution. Heavy organic waste loads from Covington are diluted in this river segment by the relatively unpolluted waters of the Cowpasture River. Low dissolved oxygen levels encourage the invasion of rough fish. However, water quality standards adequate for fish survival are present except on rare occasions. Tainted fish flesh seems to be the major problem in this area. According to the local game wardens and biologists, the unpleasant flavor of the fish greatly reduces sport fishing demand.

JACKSON RIVER - Mile 339.7 - 343.8

1. Location: The entire section of the Jackson River from Clifton Forge, Virginia, to the confluence of the Cowpasture River.
2. Data Reference: 1, 4, 5.
3. Pollution Sources: (a) Covington residential and industrial wastes; (b) Clifton Forge residential and industrial wastes; (c) organic wastes from Covington and an unknown chemical substance from Clifton Forge are thought to be the main pollutants.
4. Pollution Effects: Fishery resources are moderately affected by pollution. While organic waste loads from Covington cause low dissolved oxygen concentrations, the river is recovering in this stream segment. The 1966 VMI Study[4] revealed dissolved oxygen ranged from 0.1 mg/l to 5.1 mg/l. Fish survival under these circumstances is doubtful. However, this situation does not prevail all year long. Water quality parameters are near survival levels in portions of the segment under the most adverse circumstances. Fish are thought to migrate into the area for a greater part of the year in substantial numbers. Compounding the dissolved oxygen problem is the report of bad tasting fish flesh. Chemicals or compounds causing this flavor problem are unknown at present, but the source is thought to be Clifton Forge industrial wastes.

JACKSON RIVER - Mile 343.8 - 363.6

1. Location: The entire section of the Jackson River from Covington to Clifton Forge, Virginia
2. Data Reference: 1, 2, 3, 4, 5.
3. Pollution Sources: (a) Covington residential and industrial wastes; (b) the West Virginia Pulp and Paper Company is thought to be the main pollution source contributing a huge quantity of organic effluent.
4. Pollution Effects: Fishery resources are severely affected by pollution. Oxidation of large quantities of organic material from Covington reduce dissolved oxygen concentrations throughout the entire stream segment. A recent scientific study by VMI[4] revealed dissolved oxygen levels in this area averaged below 1 mg/l. State studies[5] also showed water quality was poor. Fish require a minimum average of 5 mg/l, and at no time should dissolved oxygen drop below 3 mg/l. Based on the above water quality results, fish life and many associated food chain organisms could not survive. However, a total fishery loss was not assigned to this river section. During certain periods of the year a combination of increased flow and cold water temperatures reduced the pollution effect. At this time some fish recruitment takes place. An example is the yearly spring run of suckers that passes through the area. Despite the occasional presence of fish, the waters in this river section are virtually worthless, providing only occasional low quality fishing opportunity.

UPHAM CREEK - Mile 0.0 - 3.2

1. Location: The stream is located just north of Richmond, Virginia.
2. Data Reference: 1.
3. Pollution Sources: Probably domestic sewage from Richmond, Virginia.
4. Pollution Effects: Fishery resources are severely affected by pollution. High organic waste loads from the Richmond area periodically reduce stream dissolved oxygen concentrations to critical levels. Fish populations are low and composed of hardier less desirable species.

WHITE OAK SWAMP - Mile 6.3 - 7.3

1. Location: Near Elko, Virginia
2. Data Reference: 1.
3. Pollution Sources: Elko sewer wastes.

4. Pollution Effects: The small stream segment is severely affected by pollution. Oxygen levels in this small section of White Oak Swamp are reduced to critical levels during warm weather periods. Fish populations are extremely low. Undesirable esthetic traits of the stream preclude sport fishing effort in the area.

BAILEY CREEK - Mile 0.0 - 3.5

1. Location: This section of Bailey Creek is located just east of Hopewell, Virginia.
2. Data Reference: 1, 2, 5, 7.
3. Pollution Sources: (a) Hercules Powder Company; (b) residential pollution of Hopewell; (c) Fort Lee, Virginia, military reservation wastes.
4. Pollution Effects: Fishery resources are totally eliminated from this creek segment. Oxidation of organic wastes reduces this stream to an aseptic condition. Water quality tests conducted by the State[5] have shown a complete lack of dissolved oxygen in the creek. Plant and animal life are reportedly absent.

APPOMATTOX RIVER - Mile 0.0 - 12.2

1. Location: The entire stream segment from Petersburg to Hopewell, Virginia
2. Data Reference: 1.
3. Pollution Sources: (a) Petersburg residential and industrial wastes, (b) Hopewell residential and industrial wastes.
4. Pollution Effects: Fishery resources are moderately affected by pollution. Water quality data available does not indicate substandard water conditions in this stream segment; however, large quantities of organic waste from Hopewell and Petersburg are thought to reduce dissolved oxygen levels of the river below optimum conditions for fish. Various other deleterious waste substances from Hopewell industries are thought to be present. Resident fishery resources are composed primarily of moderate populations of rough fish species. A large anadromous spawning run passes through the area yearly, providing significant fishing opportunity.

RIVANNA RIVER - Mile 32.3 - 36.3

1. Location: A segment of the Rivanna River east of Charlottesville and below Moores Creek.
2. Data Reference: 1.
3. Pollution Sources: Charlottesville industrial and residential wastes.
4. Pollution Effects: Fishery resources are lightly affected by pollution. Organic wastes from Charlottesville reduce dissolved oxygen concentrations in the river segment during warm weather periods. No fish kills have been reported. Although water quality data is unavailable, it is believed poor environmental conditions prevail. This situation encourages the invasion of rough fish species and reduces the abundance of fish.

RIVANNA AND NORTH FORK RIVANNA RIVER - Mile 41.0 - 42.4

1. Location: Just east of Charlottesville, Virginia.
2. Data Reference: 1.
3. Pollution Sources: Sand and gravel dredging operation.
4. Pollution Effects: Fishery resources are lightly affected by pollution. Suspended solids in this small section of the river reduce productivity of the water, encourage invasion of rough fish, and interfere with local spawning activities.

MOORES CREEK - Mile 0.0 - 5.5

1. Location: This creek borders the southern edge of Charlottesville, Virginia
2. Data Reference: 1, 2.
3. Pollution Sources: (a) Charlottesville Woolen Mill, (b) Charlottesville sewage plant #1.
4. Pollution Effects: Fishery resources are totally eliminated from this creek segment. Although no water quality data is available, wardens report the stream is in an aseptic condition and is unable to support fish life.

MECHUM RIVER - Mile 0.0 - 9.6

1. Location: The entire stream segment from the vicinity of Batesville, Virginia, to its confluence with Moormans River.
2. Data Reference: 1.
3. Pollution Sources: Mortons Frozen Foods.
4. Pollution Effects: Fishery resources are severaly affected by pollution. No water quality data is available for this

river segment. Large organic waste loads from Mortons Frozen Foods severely reduce dissolved oxygen stream concentrations. Fishery resources in the affected area are composed primarily of low populations of rough fish. Populations are thought to migrate to better water areas when extremely adverse water quality conditions prevail. Occasionally small fish kills occur.

HARDWARE RIVER - Mile 11.9 - 27.3

1. Location: The entire river segment from Red Hill, Virginia, to the Albemarle-Fluvanna County Line.
2. Data Reference: 1.
3. Pollution Sources: Unknown.
4. Pollution Effects: Fishery resources are lightly affected by pollution. Heavy silt loads reduce light penetration and productivity of the water, in addition to affecting spawning success. A fishery composed of large numbers of more tolerant rough fish is thought to occupy the stream because of poor water quality and habitat conditions.

TYE RIVER - Mile 0.0 - 15.1

1. Location: Stream segment from the confluence of Piney River to the confluence of Buffalo River. The latter stream is located a few miles west of Buffalo Station, Virginia.
2. Data Reference: 1, 7.
3. Pollution Sources: American Cyanamid.
4. Pollution Effects: Fishery resources are severely affected by pollution. Piney River acid wastes are diluted and buffered by mixing waters of the Tye River. Aquatic conditions of this river section border near tolerance limits of fish. Both productivity and carrying capacity of the stream are very low. Occasionally a fish kill occurs because of acid conditions.

PINEY RIVER - Mile 0.0 - 5.0

1. Location: Stream segment from Piney River, Virginia, to the confluence of the Tye River.
2. Data Reference: 1, 2, 5, 7.
3. Pollution Sources: American Cyanamid.
4. Pollution Effects: Fishery resources are totally eliminated from this river segment. Sulfuric acid wastes from American Cyanamid reduce pH levels in the stream far below fish tolerance levels. Hydrogen ion concentrations of around pH 6 are considered a minimum acceptable level for fisheries.

FISHING CREEK - Mile 0.0 - 1.2

1. Location: The entire length of this creek segment runs through suburban Lynchburg, Virginia.
2. Data Reference: 1.
3. Pollution Sources: A meat packing plant and cannery are major pollution sources.
4. Pollution Effects: Fishery resources are severely affected by pollution. Large quantities of organic material reduce stream dissolved oxygen concentrations significantly according to local wardens. Fishery populations composed of low numbers of rough fish survive in the section of the creek adjacent to the James River. Upper portions of the creek are void of fish life.

MAURY RIVER - Mile 0.0 - 12.5

1. Location: The entire river segment from Buena Vista, Virginia, to the James River.
2. Data Reference: 1, 2.
3. Pollution Sources: (a) Industrial and residential wastes of Buena Vista; (b) several industries contributing significant waste loads are Piedmont Paper Products, Inc., Leas McVitly Tanning Company, and a limestone and rubber treatment plant near Buena Vista.
4. Pollution Effects: Fishery resources are lightly affected by pollution. A combination of silt, deleterious chemicals, and reduced dissolved oxygen levels is thought to reduce the productivity of the stream and encourage the presence of rough fish species.

MAURY AND CALFPASTURE RIVERS - Mile 20.4 - 46.5

1. Location: The entire river segment between Goshen and Lexington, Virginia
2. Data Reference: 1.
3. Pollution Sources: Silt of unknown origin.
4. Pollution Effects: Fishery resources are lightly affected by pollution. High stream silt loads are thought to reduce the quality of habitat and encourage the presence of rough fish species.

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APPENDIX C

Population Projections for Major Municipal Areas in the James River Basin

POPULATION PROJECTIONS FOR MAJOR MUNICIPAL
AREAS IN THE JAMES RIVER BASIN

Area	1960	1965*	1970	1980	1990	2000	2010	2020
Charlottesville	42,979	46,000	52,000	72,000	89,000	91,000	93,000	96,000
Clifton Forge-Covington	28,458	28,800	29,000	28,000	28,000	28,000	29,000	32,000
Hampton-Newport News	219,132	250,000	269,000	291,000	320,000	362,000	418,000	489,000
Lexington-Buena Vista	25,159	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Lynchburg	85,681	95,000	107,000	143,000	193,000	253,000	329,000	420,000
Norfolk-Portsmouth	525,818	570,000	603,000	626,000	769,000	795,000	882,000	1,001,000
Petersburg-Hopewell	111,920	120,000	141,000	198,000	270,000	344,000	457,000	573,000
Richmond	383,371	420,000	453,000	565,000	676,000	754,000	827,000	906,000
Suffolk	39,655	42,000	44,000	49,000	49,000	49,000	49,000	49,000

* Interpolated for computational reasons.

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WATER QUALITY AND POLLUTION CONTROL STUDY
CHESAPEAKE BAY DRAINAGE AREA

JAMES RIVER BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

FIGURE 1